1. INTRODUCTION

1.1. Purpose

The transportation community has been developing and operating computer-based transportation systems since the early 1970s. At that time many of the core building blocks of today's systems were introduced including traffic surveillance cameras, changeable message signs, traffic responsive signal operation, transit priority treatment, highway advisory radio and ramp metering. Since these systems were typically not interconnected and were operated with individual computer systems, separate operational guidelines were established – one for each system.

While computer technology changed during the 1980s and more sophisticated control and monitoring capabilities were devised, the systems and technologies remained separated. It wasn't until the 1990s that the transportation community embarked on a journey to integrate systems and to incorporate evolving technologies (like the Internet and personal communications devices) to leverage the effectiveness of their tools. This strategy, Intelligent Transportation Systems (ITS), requires a paradigm shift in our understanding of the entire transportation system in order to manage the transportation network. No longer are we operating individual systems — instead we are building and operating integrated, interdependent systems where our collective actions are focused on providing transportation services to our customers.

This Handbook Guide describes the development of a Transportation Management Center (TMC) Manual in the context of the integrated, interdependent world of ITS systems. It describes why operations manuals are important; it identifies the activities and participants needed to produce and update a TMC Manual; and it provides a checklist of topics that can jump start the development of a TMC Manual.

This document also contains case studies illustrating transportation community practices that have been applied to development and use of TMC manuals.

Sponsorship for the development of this Guide was provided with the help of the U.S. Department of Transportation TMC Pooled-Fund Study Project. Members of the TMC Pooled Fund Review Team provided oversight to this Handbook and were influential in shaping this product.

Readers of this Handbook are encouraged to review the TMC Pooled-Fund web site where additional TMC operational resources are provided including example TMC Operations Manuals. At the time of printing the Pooled-Fund web site was located at http://tmcpfs.ops.fhwa.dot.gov.

DOCUMENT STRUCTURE

This Guide is divided into three parts.

- The first describes why operations manuals should be developed.
- The second describes how to develop an effective operations manual.
- The third part provides a checklist of topics that can jump start the development of a TMC Manual

1.2. Intended Audience

1.2.1. Institutional Perspective

This Handbook is a resource for individuals who are responsible for or involved in managing, developing, implementing, operating, maintaining, or supporting a transportation management system.

This Handbook is a resource for individuals who are responsible for or involved in managing, developing, implementing, operating, maintaining, or supporting a transportation management system.

The National ITS Architecture provides a framework for defining and under-standing the variety of centers, field devices, vehicles and travelers in the transportation system. This high level perspective of the transportation sys-tem is maintained by the U.S. Department of Transportation and updated periodically. At the time of printing Version 5.0 of the Architecture was available and was posted at the following website: http://www.iteris.com/itsarch/.

Figure 1 shows the centers, field devices, vehicles and travelers in the National ITS Architecture. This drawing depicts the "physical entities" in the Architecture and their relationships with one another. While the Architecture provides a comprehensive view of transportation, this Handbook and the TMC Pooled Fund Study focus on issues that arise from transportation management centers that are part of traffic signal control systems, freeway management systems, or multi-modal systems. (1) From the Architecture perspective the functions associated these systems would typically be found in the centers for Traffic Management and Transit Management. However, with the practice of co-locating centers and sharing duties during off-hours, the Handbook may apply to other center configurations as well.

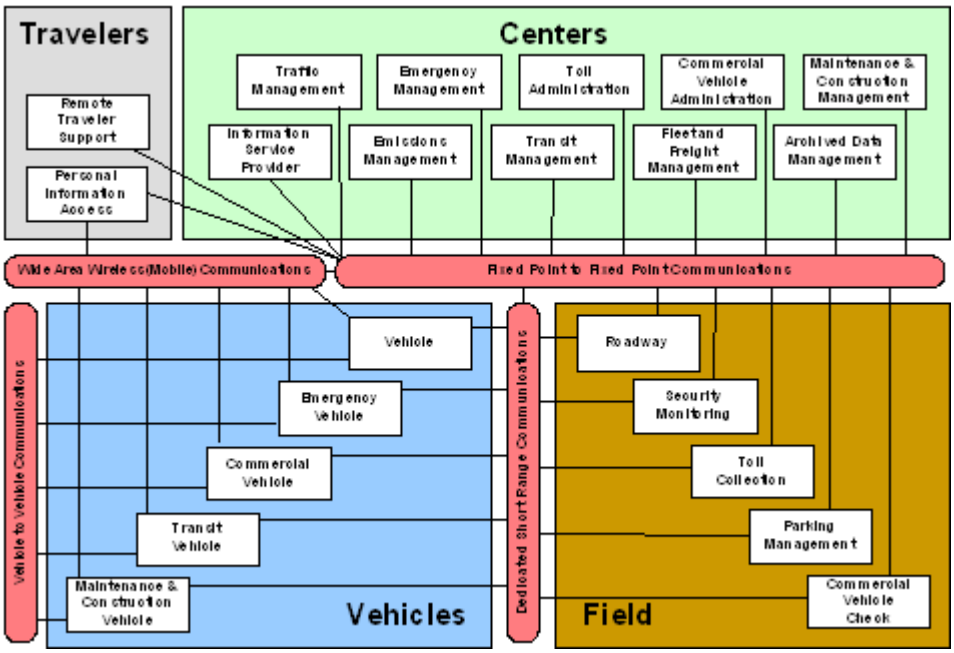

Figure 1 -- National ITS Architecture

According to the National ITS Architecture Mission Definition document, the kinds of agencies that are typically responsible for Traffic Management and Transit Management infrastructure functions include (2):

The National ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems.

- State Agencies
- Metropolitan Planning Organizations
- City Agencies
- County Agencies
- Toll Authorities

The ITS Architecture helps define the institutions, the services and functions that are performed and the information flows that connect the components of the transportation system.

Therefore, from an institutional perspective this Handbook applies to traffic management and transit management centers that are concerned with traffic signal control systems, freeway management systems, or multimodal systems. And these functions are typically operated by state agencies, metropolitan planning organizations, city agencies, county agencies and toll authorities.

1.2.2. Staffing Perspective

Handbook focuses on issues that arise from transportation management centers that are part of traffic signal control systems, freeway management systems, or multimodal systems.

From a personnel perspective the Handbook has applicability to a number of staffing categories. Perhaps the most commonly named TMC staff member is the Transportation Management Operations Technician. This individual is the person who has daily "hands-on" responsibility for some of the following tasks.

- Provide Travel Information
- Records Management
- Congestion Management
- Failure Management
- Incident Management
- Special Event Management
- Traffic Flow Monitoring
- Emergency Management
- Provide/Coordinate Service Patrols
- Reversible and High Occupancy Vehicle (HOV) Lane Management
- Traffic Signal System Management
- Transit Vehicle Monitoring
- Advanced Public Transportation Systems (APTS) Management
- Environmental and RWIS Monitoring
- Overheight Vehicle Management
- Rail Crossing Management

A document titled *Guidelines for TMC Transportation Management Operations Technician Staff Development (TMOT Guidelines)* describes the knowledge, skills and abilities (KSAs) associated with a staff member who is performing the tasks noted above. (3).

In addition to operators, a number of other types of positions are affiliated with development and operations of Intelligent Transportation Systems. In the late 1990s the FHWA sponsored the development of a series of capacity building documents to identify the skills needed for ITS workers. (4) Those documents include a list of affiliated personnel arranged by the role they play in developing, implementing and operating ITS systems. While the intended audience for a TMC Operations Manual primarily includes operators, dispatchers, drivers, electronics technicians, and managers listed in the third bulleted list below, others in this list have a role in providing content for the Manual.

- Roles in Developing a Regional ITS Concept of Operations and Planning for ITS
  - Champions
  - Planners
  - Federal Field Staff
- Cross-Cutting Roles
  - Business Analysts
  - Data(base) Analysts and Managers
  - Contract Specialists
  - Legal Staff
  - Marketing / Public Relations Staff
  - Human Resources Staff
  - Systems Administrators/ Support Technicians
- Roles in the Design, Procurement, Installation, Operations & Maintenance, and Evaluation Stages
  - Project Managers
  - Software Developers
  - Systems Designers / Integrators
  - Operators
  - Dispatchers
  - Drivers
  - Electronics Inspection and Maintenance Technicians
  - Operations Managers/Supervisors
- Creating Change: Roles for Mainstreaming ITS
  - Program/Agency Manager
  - Inter-jurisdictional Coordinator

1.2.3. Role in the Life Cycle of a Project

Projects that have involved traffic management centers typically followed a systems engineering life cycle. And current practice required by the

U.S. DOT on January 8, 2001 require that Intelligent Transportation Systems projects carried out using funds from the Highway Trust Fund including the Mass Transit Account conform to the National ITS Architecture and applicable ITS standards. These goals are being accomplished through the development of regional ITS architectures and the use of a systems engineering process for ITS project development. (5)

According to Section 940.11.c of the FHWA rule, the systems engineering analysis includes at a minimum:

- Identification of portions of the regional ITS architecture being implemented (or if a regional ITS architecture does not exist, the applicable portions of the National ITS Architecture);
- Identification of participating agencies roles and responsibilities;
- Requirements definitions;
- Analysis of alternative system configurations and technology options to meet requirements;
- Procurement options;
- Identification of applicable ITS standards and testing procedures; and
- Procedures and resources necessary for operations and management of the system.

Current practices typically represent the systems engineering process in a "Vee" Figure 2 shown below. (6) The general shape of the model is that of the letter "V" as shown. This model is simply a graphical representation of a process that can be followed throughout the life-cycle of a project. The left hand side of the "Vee" depicts the decision making process that must come before actual system construction and implementation. Each task adds more detail.

A TMC Manual should be written throughout the life of a project.

The point of this discussion is that some content for a TMC Operations Manual should be developed throughout the life cycle of a system. Potential content for a TMC Operations Manual includes concepts of operations, a description of key functions of the center, goals of the system, and other items that are developed at various stages in the life cycle of a system and center. A TMC Operations Manual should not be developed at the end of a project, but should be developed throughout the life of a system or center.

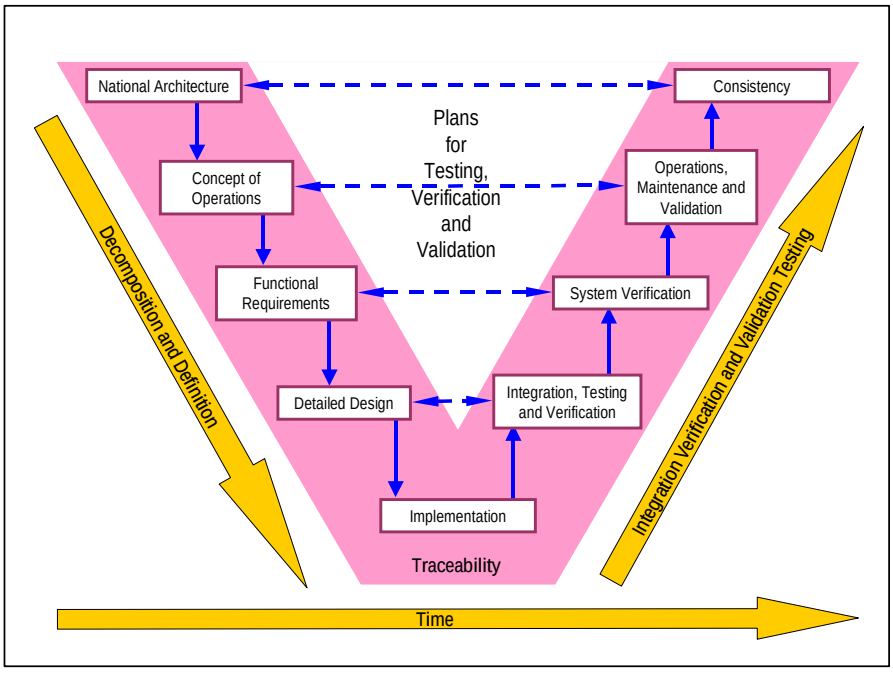

Figure 2 -- Vee Systems Engineering Process

1.3. How was the Handbook Developed?

This Handbook was developed collaboratively with the TMC Pooled Fund Study Review Team. The Review Team members included public sector representatives who brought relevant experience to the project tasks and were able to help shape the result so that it is relevant to the intended audience. In addition a number of associated resources were used to add value to the final product including (1) existing TMC manuals, (2) a recommended outline for a TMC manual produced by the Institute of Transportation Engineers in 2001, and (3) documents that cover developmental and operational characteristics such as systems engineering and staffing.

The process for developing the document included writing and iteratively editing three versions of the outline for the Handbook. After the final outline was approved by the TMC Pooled Fund Study Review Team, the authors wrote three versions of the technical document. Each document draft was reviewed by the TMC Pooled Fund Study Review Team and changes were made that reflected the experience of the Team. The Handbook's guidance was enhanced by (a) the inclusion of case studies and (b) the addition of an updated TMC Manual outline that can serve as a checklist for TMC Operations Manual development.

In addition a distribution plan and some supporting outreach material were developed tailored to relevant audiences.

1.4. Overview of Handbook Content

The Handbook is structured into three parts.

- The first describes the Handbook and explains why operations manuals should be developed.
- The second describes how to develop an effective operations manual.
- The third part provides a checklist of topics that can jump start the development of a TMC Manual.

Taken together and augmented with example TMC operations manuals, the guidance found in this Handbook allows an agency to involve relevant staff who can contribute their content to a TMC operations manual that will meet the needs of both the operating agencies involved and the staff responsible for this activity.

This Handbook allows an agency to involve relevant staff to develop an Operations Manual that meets the needs of both the agency and the staff.

1.5. Organization of the Handbook

Part I

Part I provides an overview background of the Handbook. It contains an introduction that describes the purpose, audience and organization of the document. It also provides an overview of traffic management centers including a high level concept of operations, institutional considerations and key topics relevant to operations. And finally it describes why a TMC operations handbook should be developed. Part I is divided into three chapters as follows.

- Chapter 1 of the Handbook states the purpose of this document, identifies the intended audience groups, summaries how the Handbook was developed and the role of the TMC Pooled Fund Study Review Team, summarizes the structure of the Handbook, indicates the state-of-the-practice in 2005, and shows where relevant resources can be found.
- Chapter 2 contains an overview of the Traffic Management Centers. It includes a high level concept of operations, provides a summary of key institutional issues relevant to a TMC, the types of operations that are typical of these centers, and key topics applicable to daily operation.
- Chapter 3 describes the need for and the challenges in sustaining a TMC operations manual. It also highlights successful practices that can be applied to leverage the actions leading

Part II

Part II defines the major components of the TMC operations manual, provides guidance on how to create and update the manual, and provides case studies of TMC operations manual development and use. Part II is divided into four chapters as follows.

Chapter 4 describes approaches for developing an operations manual based on the maturity of the TMC and its organizational setting.

Chapter 5 helps an agency review their organizational structure and setting in order to identify the components of a TMC Operations Manual needed for their situation. It will also cross-reference the checklist contained in Part III.

Chapter 6 identifies the methods, processes, techniques, and tools to develop and update an Operations Manual for TMCs.

Chapter 7 provides examples or case studies that build off of and demonstrate how the concepts, techniques, and guidance that are identified in the earlier chapters can be applied within an agency or program associated with a TMC or traffic operations program.

Part III

Part III provides a checklist of topics that can be included in a TMC operations manual. Part III contains one chapter, Chapter 8, and supplemental appendices.

Chapter 8 supplements the material provided in earlier chapters with quick descriptions of the topics to be included in a TMC manual.

1.6. How to Use the Handbook

<Section 1.6 to be completed in Draft 2>

As stated in Section 1.2.1, this Handbook is a resource for individuals who are responsible for or involved in managing, developing, implementing, operating, maintaining, or supporting a transportation management system. With that perspective the personnel identified in Section 1.2.2 have the ability to contribute content and guidance for a TMC Operations Manual in the following manner.

<This table will be updated during the development of Draft 2. Another perspective, such as TMC maturity, may also be addressed. Two brief examples are provided to exemplify the concept.>

Table 1 -- Role in Developing a TMC Operations Manual

Typical User / Contributor	Activity

Table 1 -- Role in Developing a TMC Operations Manual

Typical User / Contributor	Activity
Roles in Developing a Regional ITS Concept of Operations and Planning for ITS	
o Champions	
o Planners	1. Provide information about the regional ITS Plan which may be useful in characterizing the Concept of Operations cited in Section XX of this Handbook.
o Federal Field Staff	
Cross-Cutting Roles	
o Business Analysts	
o Data(base) Analysts and Managers	
o Contract Specialists	
o Legal Staff	
o Marketing / Public Relations Staff	
o Human Resources Staff	
o Systems Administrators/ Support Technicians	
Roles in the Design, Procurement, Installation, Operations & Maintenance, and Evaluation Stages	
o Project Managers	
o Software Developers	
o Systems Designers / Integrators	
o Operators	
o Dispatchers	
o Drivers	
o Electronics Inspection and Maintenance Technicians	
o Operations Managers/Supervisors	
Creating Change: Roles for Mainstreaming ITS	
o Program/Agency Manager	
o Inter-jurisdictional Coordinator	1. Provide information about the regional ITS Plan which may be useful in characterizing the Concept of Operations cited in Section XX of this Handbook.

1.7. State-of-the-Practice

The purpose of the TMC Pooled Fund Study is to initiate projects that address operational and human-centered issues associated with TMCs. Since a TMC operations manual has the capability to assist the interaction of operational staff with TMC technology, it meets the objective of the Pooled Fund Study Team.

In the 2004 – 2005 timeframe many public agencies and practitioners did not recognize the need, importance, and value of an operations manual. And many were also unaware of how to effectively integrate the use of an operations manual into their daily activities, procedures, policies and programs.

The Institute of Transportation Engineers had developed an outline identifying the key issues and topics that should be covered in an operations manual. Technical guidance and recommended practices had not been developed and made available to assist practitioners on how to develop, what to include and how to integrate an operations manual into the day-to-day tasks, policies, and procedures, and activities. The TMC Pooled Fund Study had gathered a few example TMC operations manuals and made them available through their public web site.

This state-of-the-practice provided the backdrop that led the TMC Pooled Fund Study Team to identify the development of this Handbook as a work project. It was judged a priority to the members and to the larger TMC community; and it met the objectives and requirements of the program.

1.8. Resources

<Section 1.8 to be developed in Draft 2>

<The approach of this section will not be to list a five page bibliography for a TMC Operations Manual as is posted on the Pooled Fund Study website for this project. Instead the suggested approach is to provide a list of key documents with short descriptions. The selection of a couple of dozen the key documents will depend on the final content for this handbook. The structure of the resource description could be similar to that found in Section 1.9 below. Some of the candidate documents that may be included are as follows.>

- *Metropolitan Transportation Management Center Concepts of Operations*. Intelligent Transportation Systems. Report No FHWA-JPO-99-020. Oct. 1999. http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/8ff01!.pdf
- *TMC Concepts of Operation: Implementation Guide*. ITS Joint Program Office, Federal Highway Works Administration, December 1999. http://tmcpfs.ops.fhwa.dot.gov/cfprojects/uploaded_files/TMCConOpsImplmGuide.pdf
- *Developing Functional Requirements for ITS Projects*. Report No FHWA-OP-02-047. April 2002. http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE/13621.html

- *Developing and Using a Concept of Operations in Transportation Management Systems*. December 2004. http://tmcpfs.ops.fhwa.dot.gov/cfprojects/new_detail.cfm?id=38&new=0.
- *Building Quality Intelligent Transportation Systems Through Systems Engineering*. 1992. http://itsdocs.fhwa.dot.gov/jpodocs/repts_te/13620.html
- *Guidelines for TMC Transportation Management Operations Technician Staff Development*. FHWA Report FHWA-OP-03-071. http://tmcpfs.ops.fhwa.dot.gov/cfprojects/new_detail.cfm?id=26&new=2.
- ITE Recommended Outline for a TMC Operations Manual. http://tmcpfs.ops.fhwa.dot.gov/cfprojects/uploaded_files/ITE%20OM%20Annotated%20Outline.pdf.

1.9. Notes and References

1 The Charter of the Transportation Management Center Pooled-Fund Study initiative is located on http://tmcpfs.ops.fhwa.dot.gov/overview.cfm.

2 The National ITS Architecture contains a series of documents that describe its components. One of those documents, the *National ITS Architecture Mission Definition*, contains a section describing the users of the transportation system. In the October 2003 version Table 3.3-1 lists those users including the transportation infrastructure providers. See http://www.iteris.com/itsarch/html/menu/documents.htm to obtain a copy of *Mission Definition*. This document is also available through the ITS Electronic Document Library at http://www.its.dot.gov/itsweb/welcome.htm.

3 FHWA Report FHWA-OP-03-071, *Guidelines for TMC Transportation Management Operations Technician Staff Development* by Daniel H. Baxter, is available from the Pooled Fund web site as a product of a completed project called "TMC Operator Requirements & Position Descriptions, Phase 1." This site is http://tmcpfs.ops.fhwa.dot.gov. The document uses requirements matrices to show the relationships between TMC functions, operations personnel tasks, and the knowledge, skills, and abilities a person must possess to accomplish the required tasks. Training requirements for operations personnel are discussed.

4 These professional capacity building documents are available through the ITS Electronic Document Library at

http://www.its.dot.gov/itsweb/welcome.htm. The series was titled "Building Professional Capacity in ITS" and contained documents describing staffing, hiring and development of a training program. The documents are numbered FHWA-OP-99-016, FHWA-OP-99-017, FHWA-OP-99-018, FHWA-OP-99-019, and FHWA-OP-99-033.

5 The text of the U.S. DOT Final Rule and Final Policy on ITS can be found on the web at http://ops.fhwa.dot.gov/its_arch_imp/index.htm.

6 The 1992 document *Building Quality Intelligent Transportation Systems Through Systems Engineering* gives an explanation of the systems engineering approach and describes the VEE diagram. It is available through the ITS Electronic Document Library at http://www.its.dot.gov/itsweb/welcome.htm. The document number is FHWA-OP-02-046.

2. OVERVIEW OF TRAFFIC MANAGEMENT CENTERS (TMC)

2.1. Introduction

An operations manual is a critical tool that can support the management of day-to-day TMC operation by defining the roles, responsibilities, functional capabilities, services provided, major tasks, and other day-to-day activities that are performed in pursuit of an agency's mission, goals, and objectives.

Operations affect outcomes. With more effective operations there is more effective system performance. And an operations manual is a key tool in leveraging effective operations.

Operations affect outcomes. With more effective operations there is more effective system performance.

In particular the potential benefits resulting from the development and use of a TMC operations manual include the following.

(1) Operational procedures that will, in turn, lend consistency to day-to-day activities, improve inter-agency and inter-jurisdictional working relationships and ease internal training efforts;

(2) System maintenance, monitoring and security procedures that will improve resource utilization and enhance system safety; and

(3) Data collection, analysis and warehousing procedures that will support short- to long-term transportation facility performance improvements and planning efforts.

Benefits of a TMC Manual:

Enable inter-agency and inter-jurisdictional relationships

Improve resource utilization

Improve transportation system performance

This chapter sets the framework around which a TMC functions within overall traffic operations in the region. The chapter highlights the importance of understanding the institutional considerations of a TMC from the perspective of the participating agencies prior to moving forward with developing a handbook.

Chapter 2 also provides a high-level overview of an operations manual, identifies the requirements in an operations manual, and describes how those requirements relate to and are important in day-to-day operations of a TMC.

This chapter is the second of XX in this Handbook. The content of the following chapters is described below.

Chapter 3, Why Develop a TMC Operations Manual?; This chapter describes; (1) the motivation for developing a TMC operations manual specific to one's locale, (2) the potential resultant benefits in achieving agency goals and supporting regional strategies, (3) key issues for consideration before and during the TMC operations manual development process, (4)

strategies for successful TMC operations manual development using a concept of operations framework to define content and (5) examples of successful developments from around the nation.

Chapter 4, Getting Started; This chapter describes the roles and relationships of a TMC with various management structures. It also outlines at a high level some of the basic preparatory steps that will be further detailed in subsequent sections.

Chapter 5, TMC Operational Manual Components; This chapter describes the components that could be included in a TMC Operations Manual.

Chapter 6, Developing and Updating a TMC Operations Manual; This chapter presents a methodology for a systematic and on-going process of evaluation.

Chapter 7, Case Study 1; This chapter provides examples of successful practices in developing and implementing TMC Manuals.

Chapter XX, Case Study #; This chapter provides examples of successful practices in developing and implementing TMC Manuals.

Chapter XX, TMC Manual Checklist; This chapter supplements the material provided in earlier chapters with quick descriptions of the topics to be included in a TMC manual.

2.2. Concept of Operations

The specific content of a TMC operations manual will vary based on the structure, operation (i.e. services provided), agency participation and institutional context of the TMC. However, general content should include a description of: (1) daily operations including TMC functions, hours of operation, staffing, etc., (2) policies, plans and procedures to support daily operations (i.e., managing recurrent congestion, managing incidents, providing traveler information, etc.), (3) routine, preventative and emergency maintenance procedures and (4) TMC equipment and system devices (i.e., inventory) and any supporting documentation.

In order to make a document with this content effective in leveraging operations it should have a concept of operations that is consistent with regional policies, agency goals and objectives. Development of a TMC concept of operations is a mechanism for tying operations to those targets.

In general, a TMC concept of operations defines what the center accomplishes (i.e., functions), and how it goes about accomplishing it (i.e., procedures). The concept of operations addresses both operations and maintenance of the TMC, and the resources for which it is responsible. It describes the interactions that occur within the TMC, and between the TMC and its partners (firms and agencies) and customers (motorists, media, etc.) in managing transportation.

Concept of operations defines what the TMC accomplishes and how it gets done.

Since the Final Rule on Architecture and Standards Conformity requires "an operational concept that identifies the roles and responsibilities of participating agencies and stakeholders in the operation and implementation of the systems included in the regional ITS architecture", many regions will be able to use their ITS Architecture work as a resource to define TMC operations.

A handbook for the development of a TMC concept of operations was sponsored by the TMC Pooled Fund Study. This document

In addition a number of regions within the U.S. have posted their ITS Architecture to web sites. Therefore many examples of a regional concept of operations are available. While fewer specific TMC concepts of operations have been posted online, it

This section will suggest using the ITS Architecture work to leverage the development of a TMC concept of operations.

2.3. Structural and Institutional Considerations

The National ITS Architecture provides a list of "functions" that can be performed by traffic management systems and the transit management systems. These functions (called equipment packages in the National ITS Architecture) include the following.

Functions a TMC can perform are called market packages in the National ITS Architecture.

- Barrier System Management
- Collect Traffic Surveillance
- Highway-rail intersection (HRI) Traffic Management
- Rail Operations Coordination
- Safeguard System Management
- TMC Environmental Monitoring
- TMC Evacuation Support
- TMC for AHS
- TMC Freeway Management
- TMC HOV Lane Management
- TMC Incident Detection
- TMC Incident Dispatch Coordination/Communication
- TMC Input to In-Vehicle Signing

- TMC Multimodal Coordination
- TMC Multimodal Crossing Management
- TMC Probe Information Collection
- TMC Regional Traffic Control
- TMC Reversible Lane Management
- TMC Signal Control
- TMC Speed Monitoring
- TMC Toll/Parking Coordination
- TMC Traffic Information Dissemination
- TMC Traffic Network Performance Evaluation
- TMC Work Zone Traffic Management
- Traffic Data Collection
- Traffic Maintenance
- Transit Center Security
- Transit Evacuation Support
- Transit Garage Operations
- Transit Environmental Monitoring
- Transit Data Collection
- Transit Center Tracking and Dispatch
- Transit Center Paratransit Operations
- Transit Center Multi-Modal Coordination
- Transit Center Information Services
- Transit Garage Maintenance
- Transit Center Fare and Load Management
- Transit Center Fixed-Route Operations

Services a TMC can provide using the functions it performs are called Market Packages in the National ITS Architecture.

These functions can be used to provide ITS services such as traffic incident management or freeway control. These services are called market packages in the National ITS Architecture. Services typical for TMCs that might use this Handbook include the following.

- Network Surveillance
- Probe Surveillance
- Surface Street Control
- Freeway Control
- HOV Lane Management
- Traffic Information Dissemination
- Regional Traffic Control
- Traffic Incident Management System
- Traffic Forecast and Demand Management
- Electronic Toll Collection
- Emissions Monitoring and Management
- Virtual TMC and Smart Probe Data
- Standard Railroad Grade Crossing

- Advanced Railroad Grade Crossing
- Railroad Operations Coordination
- Parking Facility Management
- Regional Parking Management
- Reversible Lane Management
- Speed Monitoring
- Drawbridge Management
- Roadway Closure Management
- Transit Vehicle Tracking
- Transit Fixed-Route Operations
- Demand Response Transit Operations
- Transit Passenger and Fare Management
- Transit Security
- Transit Maintenance
- Multi-modal Coordination
- Transit Traveler Information

The selection of these services should be defined in a concept of operations for a TMC that is consistent with a regional consensus ITS architecture. That is, the region should develop an ITS architecture that sets the framework from which an ITS concept of operations can be formulated.

<In draft 2 of this Handbook additional material describing the business models available to a TMC will be provided. This discussion will be founded on the draft TMC Pooled Fund Study project to develop a handbook on "Developing and Using Concept of Operations in Transportation Management Systems" and "TMC Business Planning and Plans Handbook." The anticipated length of this discussion will be two to three pages.>

2.4. Relationship to Other Manuals, Policies and Procedures

In order for an operations manual to be effective it must be consistent with the institutional and administrative policies that help guide the environment in which it operates. This section provides a description of the kinds of documents that might be applicable and briefly indicates how they impact the operational concepts and procedures identified in an Operations Manual.

<Additional resources will be added in Draft 2.>

1. National ITS Architecture and Regional ITS Architecture documents

   These resources help define the mission, goals and objectives within which the TMC operates. They also help identify the stake-

holders, services and functions that are included as a part of a center's sphere of influence. Information from these documents would typically be included in Section XX of Chapter 5.

2. Agency Employee Manual (sometimes called a Personnel Manual)

   These manuals are typically tailored to an organization and could include topics such as compensation and classification, complaint resolution, employee relations, equal employment opportunity, payroll and work schedule information, performance appraisal, safety and emergency procedures, hiring and appointment, position classification, employee ethics and conduct and disciplinary action. Information from these sources could be included in Sections XX of Chapter 5.

3. Agency Business Procedures Manual

   These manuals describe the procedures for invoice processing, invoices, travel regulations, petty cash funds, identifications cards, risk management, account numbers, expenditure codes, budget reallocations and authorized signature forms. Information from these documents would typically be included in Section XX of Chapter 5.

4. TMC Business Planning and Plans Handbook

   The objective of this TMC Pooled Fund sponsored handbook is to outline the business planning models that have been successfully employed by transportation agencies to ensure the long-term sustainability of transportation management centers and associated Intelligent Transportation System (ITS) applications. Information from this source could be included in Sections XX of Chapter 5.

5. Developing and Using Concept of Operations in Transportation Management Systems

   The purpose of this TMC Pooled Fund sponsored handbook is to develop technical resources that provide guidance and recommended practices on the need for, development of, and use of a concept operations and corresponding requirements throughout the life cycle of TMC. Information from this document would typically be included in Section XX of Chapter 5.

6. TMC Staffing and Scheduling for Day-to-Day Operations

   <The applicability of this TMC Pooled Fund sponsored handbook will be determined in a subsequent draft of this Operations Manual Handbook.>

7. TMC Performance Monitoring, Evaluation and Reporting Handbook

   The purpose of this TMC Pooled Fund sponsored handbook is to achieve improved TMC performance monitoring, data management, evaluation and reporting practice, which will in turn, foster improved planning, design and performance management of TMCs. Information from this source could be included in Sections XX of Chapter 5.

8. National Incident Management System

   This document authored in 2004 by the Department of Homeland Security establishes a cores set of doctrine, concepts, principles, terminology and organizational processes to enable effective and efficient collaboration. All federal departments are required to adopt this document and use in support of all actions in support of state, local and tribal entities. Information from this document would typically be included in Section XX of Chapter 5.

2.5. Integrating TMC Policies and Procedures into Agency Policies and Procedures

<This section will be completed in Draft 2 of the Handbook. The strategy of the Handbook is to define a process and a checklist of items to be included in a TMC Operations Manual. The link from existing documents to the guidance of the Handbook is included throughout. Additional aspects unique to a TMC that could be new content for existing agency policies and procedures will be highlighted including: chain of command in a multi-agency center,

2.6. Key TMC Types of Operations

<In draft 2 of this Handbook additional material describing the key types of operations available to a TMC will be provided. This discussion will be founded on the draft TMC Pooled Fund Study project to develop a handbook on "Developing and Using Concept of Operations in Transportation Management Systems" and "TMC Business Planning and Plans Handbook." The TMC Operations Team seeks guidance from the Pooled Fund Study Team on the direction for this section given the description that will be included in Section 2.3 and development of the Handbooks listed earlier in this paragraph.

2.7. Key Topics for Daily Operations

<This section will be completed in Draft 2 once the outline in Section 5 is revised.>

3. WHY DEVELOP A TMC OPERATIONS MANUAL?

3.1. Introduction

3.1.1. Chapter Purpose and Key Issues

Following an introductory description of the intent and use of this Handbook and a general overview of traffic management center (TMC) structure and operation, this Chapter describes; (1) the motivation for developing a TMC operations manual specific to one's locale, (2) the potential resultant benefits in achieving agency goals and supporting regional strategies, (3) key issues for consideration before and during the TMC operations manual development process, (4) strategies for successful TMC operations manual development using a concept of operations framework to define content and (5) examples of successful developments from around the nation.

In general, TMC managers, technical staff, and operators must have a thorough understanding of the capabilities of a TMC and the resources available to assist in making sound decisions, efficiently implementing operational strategies and control plans, and employing appropriate procedures in response to current traffic conditions. An operations manual is a critical tool that can support the management of day-to-day TMC operation by defining the roles, responsibilities, functional capabilities, services provided, major tasks, and other day-to-day activities that are performed in pursuit of an agency's mission, goals, and objectives.

Most public agencies and practitioners do not recognize the wide-ranging need, importance and value of a TMC operations manual. In brief, potential benefits resulting from the development and use of a TMC operations manual relate to formalized and documented: (1) operational procedures that will, in turn, lend consistency to day-to-day activities, improve interagency and inter-jurisdictional working relationships and ease internal training efforts; (2) system maintenance, monitoring and security procedures that will improve resource utilization and enhance system safety; and (3) data collection, analysis and warehousing procedures that will support short- to long-term facility performance improvements and planning efforts.

3.1.2. Relationship to Handbook Document

This Chapter, that establishes the need for an operations manual to support TMC operations, completes *Part I - Introduction and Background* and, in combination with *Chapter 1. Introduction* and *Chapter 2. Overview of Traffic Management Center,* positions the reader well for developing a TMC operations manual specific to their locale. *Part II - Developing a*

TMC Manual (Chapters 4 through 7) leads the reader through the step-by-step process required to develop a TMC operations manual.

3.2. Challenges in Developing and Sustaining TMC Operations

On a day-to-day basis, TMC's are challenged by the unique and dynamic nature of traffic conditions. Traffic situations typically arise without warning, and the impact can create inconvenient and potentially dangerous conditions for travelers. These conditions may change rapidly, and often unpredictably. The resources used by the TMC in executing its response may be impacted by the very situation to which it is reacting. This section does not consider these day-to-day challenges but instead focuses on longer term challenges affecting the development and sustainability of TMC operations. The challenges can be categorized as follows:

- moving from a design/construct to an operate/maintain regime
- emphasis on performance monitoring and customer service
- planning for operations
- existence of multiple stakeholders
- resource constraints
- recruitment, retention and training of personnel
- technology evolution and integration and
- system failures and false alarms

Because of the variability in TMC structure, operation, agency participation and political context center to center, unique challenges may exist that are not addressed here; this discussion is limited to the more common challenges related to TMC operations.

3.2.1. Moving from a Design/Construct to an Operate/Maintain Regime

The design/construction culture that exists in many transportation agencies may prove to be a significant impediment to developing and sustaining TMC operations. Despite ever-increasing congestion and incident occurrence and customers' desire for improved reliability, security and safety, some transportation agencies have been slow to transition their focus from designing and constructing new facilities to operating and maintaining existing facilities. This lingering focus on design and construction affects the prioritization of resources to improve the existing system.

Several factors may explain this latent shift in focus to operations and maintenance. An underlying explanation may relate to the lack of institutional ownership of congestion and its related problems (FHWA 2001). While transportation agencies are an obvious candidate, traffic congestion is very often still viewed as a "public" or community problem, influenced by outside factors such as employment trends, land use patterns, the state

of the economy, etc. that are outside the control of a single institution. Secondly, there is a lack of understanding among transportation agencies and others as to the "definition" of operations and the activities that are included in this definition. This lack of understanding leads to an agency's resistance to change the status quo; believing that operations is already being done (FHWA 2001).

Despite these factors, capacity constraints and new facility costs will force transportation agencies to move towards operations as a means to improve traffic congestion. Hence, it is important to define operations in a way that is meaningful to TMC managers, technical staff, and operators, as well as agency and political decision-makers (i.e., using "operations" as an umbrella term for more specific issues and goals or using a more descriptive term(s) such as security, reliability or safety directly).

3.2.2. Emphasis on Performance Monitoring and Customer Service

However operations is defined, it is important to be able to demonstrate success at related activities. With the shift in focus from design/construct to operate/maintain, a concurrent shift in focus on customer service and performance measurement is occurring. Rather than using "output" to gage performance (i.e., number of lanes-miles constructed), the performance of operational activities is best measured using "outcomes" such as a reduction in travel time delay or incident frequency.

Performance measures should:

- be based on customer expectations
- reflect multiple concerns (i.e., mobility, reliability, travel time, predictability, public safety, traveler information, peak/off-peak travel, multimodal travel, etc.)
- support technical decisions
- be tailored to local and regional needs and be consistent with national priorities and
- provide the basis for strategic planning and political decision-making (Neudorff, et al. 2003).

To achieve these criteria, transportation agencies should, as a first step, identify and define customer needs and expectations. This may require developing methods to better understand and communicate with the customer. Based on these needs and expectations, a comprehensive set of performance measures for local, regional and national management needs should be developed; local, regional and national priorities require different data and levels of detail to support decision-making. Revising FHWA's *Conditions and Performance Report* to reflect operations per-

formance measures would help to ensure consistent performance monitoring efforts at a National level.

Concurrent with each performance measure, transportation agencies should define benchmarks for achievement. Agency leaders may tie incentives, awards, and accountability to the achievement of these performance goals. While technology (i.e., instrumentation, enabling infrastructure) and/or private-sector services can be used for data collection to support performance monitoring, few transportation agencies have adequately planned for or allocated sufficient resources to support comprehensive performance monitoring of TMC operations.

3.2.3. Planning for Operations

Transportation agencies have limited experience applying traditional planning processes to operational activities; the planning process has more typically identified and prioritized capital improvement projects rather than activity-based alternatives. Operational activities don't map well to the traditional 3-C planning process that seeks to provide continuing, cooperative comprehensive solutions to transportation challenges. With continued emphasis on operations, the traditional planning process may need to be modified to provide equal consideration of activity-based alternatives (i.e., development of an operations planning process).

To aid in the transition from the traditional planning process to a planning process that adequately considers activity-based alternatives, transportation agencies should:

- survey customers and use these results as basis for programming
- include local leaders in all aspects operations planning
- promote strong input from operations in capital planning and
- establish linkages between operations and land use and development programs (FHWA 2001).

The large geographic scope and multi-agency, multi-jurisdiction stakeholder involvement common to TMCs may make it unclear who has responsibility for planning for operations. Metropolitan Planning Organizations (MPOs) may assume a greater role in planning for operations in a TMC.

3.2.4. Existence of Multiple Stakeholders

The development and operation of a TMC not only involves several departments within the implementing agency (or agencies), but also the efforts of a variety of private sector product and service providers.

In many state transportation departments, planning, design, construction, operation, and maintenance are separate entities. These units are often also divided by lines between the headquarters organization and district offices. To achieve the desired capability and impact from the significant TMC investment, effective interaction between these units is critical at all stages: prior to it achieving operational status, on an on-going basis as it is operated and maintained, and as it evolves (FHWA 1999).

Successful transportation operations requires interaction between transportation modes, between agencies within jurisdictions, and across jurisdictional boundaries. Thus, the actions of one agency may greatly impact the conditions under which another must labor, and the ability of an agency to optimize travel conditions will almost undoubtedly depend upon cooperation between several agencies. Interactions are not limited to public sector participants. Interaction between public and private sector organizations in the TMC are increasingly common, either under more common contractual arrangement or as part of public-private partnerships (FHWA 1999).

Interagency cooperation should be a part of every phase of the TMC. A number of strategies have been recommended to ensure successful TMC operations when multiple stakeholders are involved:

- develop an interagency strategic plan that defines a common vision, purpose and goals; all interests should be included early in the development process (i.e., freight, public safety, multiple modes) and the resulting impacts and benefits should be monitored
- develop methods to get and keep non-traditional partners involved by focusing on issues of mutual concern and building on initial successes
- increase transportation agency presence in existing or new public safety forums (e.g., Governor's Office of Emergency Management)
- build cooperation around triggering events or activities (e.g., incident or event management, emergency preparedness, etc.) to establish on-going cooperation; use scenario planning to jumpstart communication and expand focus over time; use system failure as opportunity to learn and improve; leverage existing relationships and public momentum
- establish data and communication protocols among agencies; establish common frequencies among first responders; create multi-agency training and personnel management programs and
- establish a "report card" on interagency cooperation; measure results and showcase successes (FHWA 2001).

In most multi-agency, multi-jurisdictional TMCs, a coordinating forum exists to address issues, assure regular and full communication and to identify opportunities for improvement. This often takes the form of interagency committees, typically at multiple working levels (FHWA 2001).

3.2.5. Resource Constraints

Effectively incorporating operations in the planning process will help to ensure adequate resources (i.e., staffing levels and budget) for TMC operations and maintenance. As previously discussed, activity-based projects (i.e., operations) are challenged to compete effectively for resources against capital improvement projects under the traditional planning process.

TMC programs generally grow over time, as new services or new geographic regions are added. TMCs are regionally focused, looking to provide seamless travel to motorists across jurisdictional boundaries and recognizing that facility disruptions can have far-reaching impacts. Typical service areas include system efficiency, public safety, traveler information and emergency management and may include freight programs and homeland security. TMC programs may address multimodal or intermodal facilities, rural or urban environments and Interstate to local street facilities. Transportation agencies are challenged to secure sufficient resources to support these expanded services or coverage areas.

Limited awareness, understanding and flexibility of funding sources contributes to the challenge. Traditionally, ISTEA provided funds to develop and initiate TMCs but provided little funding for ongoing operations. Without on-going operations support at the National level, transportation agencies must either compete within their State or agency for funds or pursue innovative financing mechanisms or other sources of funding such as new user taxes, dedicated local sales taxes, economic development funds. Transportation agencies may also establish relationships with legislators to benefit from earmarks and encourage resource sharing with Department of Justice (DOJ), Federal Emergency Management Agency (FEMA), etc. When possible, funding requests should reflect life-cycle funding estimates for long-term operation (FHWA 2001).

3.2.6. Personnel Recruitment, Retention and Training

An artifact of the resource constraints described above, transportation agencies commonly experience limitations on both the quantity and quality of TMC personnel. Staffing budgetary constraints limit the number of operations personnel dedicated to the TMC. Staff workload, measured in terms of the number of incidents occurring which require active management, the number of vehicles dispatched and monitored, etc., is largely unpredictable and outside the control of the TMC. A small staff addressing a substantial incident management workload will require significant automation, (i.e., automatic incident detection rather than manual scanning of detector data or camera images, and recommended incident solution scenarios, rather than manually created solutions developed on-the-fly by the operator) (FHWA 1999).

Similarly, if the staffing budgetary constraints limit the agency to hiring non-degreed individuals without experience in control center operations or traffic management, then the system is the primary tool which the agency has to control the quality and effectiveness of the outcome of the operations process. In such a case, the system must serve as the "expert" supplementing the operator, rather than calling upon the operator to make skilled traffic management decisions, often under real-time crisis conditions (FHWA 1999)

Contributing to this challenge, TMCs often experience high rates of personnel turnover. Because of their limited organizational structure within the larger transportation agency, TMCs often don't provide a clear and progressive career path for personnel. Hence, they may experience a high loss of qualified TMC personnel to other areas in the organization that offer greater opportunities for promotion or to the private sector that offers more competitive salaries.

High rates of personnel turnover result in significant training costs each time new personnel are added to the TMC program. Because turnover is often difficult to predict, consequent resources for training are often not sufficiently planned for or allocated. Training for TMC maintenance is additionally challenged. Although innovative procurement methods are in place to reduce the range of needs for maintenance training (i.e., by purchasing fewer or different brands and models of the same general device), the need for training generally increases along with the age and size of the TMC system (FHWA 1999).

3.2.7. Technology Evolution and Integration

TMC managers, technical staff, and operators are not only challenged by the unique and dynamic nature of traffic conditions each day, but must also implement, operate and maintain a set of complex, potentially incompatible and rapidly evolving technologies to support their day-to-day operations. Given the typically large geographic scope, monitoring both transportation conditions and technology-based field devices requires modern communications and computing resources. Standards are developing at a rapid pace to support new ITS implementations but will do less to simplify integration with legacy systems. Throughout the course of its life, a TMC may experience multiple technology generations. Estimating the time it takes for a TMC to become operationally stable is a challenge for transportation agencies.

3.2.8. System Failures and False Alarms

The number of technological devices and complexity of the overall TMC system challenges transportation agencies to keep all aspects of the system functional. In addition, technology is not foolproof; transportation agen-

cies must develop methods for detecting and mitigating false alarms when they occur. The occurrence of system failures and/or false alarms can quickly and negatively affect an agency's credibility in the media and among individual travelers.

3.3. Why Develop a TMC Operations Manual?

The challenges described in the previous section can be addressed, in part, through the development of a TMC operations manual. A TMC operations manual is a critical tool that agencies are encouraged to develop, maintain, and use in managing and supporting the day-to-day operations and activities performed by a TMC. The purpose of an operations manual is to formalize and document the policies, plans, procedures and other support activities that are performed to achieve the TMC's mission, goals, and objectives.

The specific content of a TMC operations manual will vary based on the structure, operation (i.e. services provided), agency participation and political context of the TMC. However, general content should include a description of: (1) daily operations including TMC functions, hours of operation, staffing, etc., (2) policies, plans and procedures to support daily operations (i.e., managing recurrent congestion, managing incidents, providing traveler information, etc.), (3) routine, preventative and emergency maintenance procedures and (4) TMC equipment and system devices (i.e., inventory) and any supporting documentation. Detailed information about TMC operations manual content is provided later in this Chapter (*3.6. Concept of Operations and Requirements for a TMC Operations Manual*) and throughout *Part II - Developing a TMC Operations Manual*.

A TMC operations manual can be designed to support agencies that do not yet have but are planning to initiate a formal traffic management system or agencies with existing TMCs. A TMC operations manual goes beyond conventional "system documentation" by providing guidance to support TMC operations activities from initiation to completion. A TMC operations manual is not intended to replace or supersede State law, agency policies or other regulations; when conflicts occur, these other sources take precedence.

Most public agencies and practitioners do not recognize the wide-ranging need, importance and value of a TMC operations manual. In brief, potential benefits resulting from the development and use of a TMC operations manual relate to formalized and documented: (1) operational procedures that will, in turn, lend consistency to day-to-day activities, improve interagency and inter-jurisdictional working relationships and ease internal training efforts; (2) system maintenance, monitoring and security procedures that will improve resource utilization and enhance system safety and (3) data collection, analysis and warehousing procedures that will support

short- to long-term facility performance improvements and planning efforts. This section defines and describes the role, identifies the benefits, discusses the need for, and provides a basis for why agencies should pursue developing a TMC operations manual.

3.3.1. Formalized and Documented Operational Procedures

Formalizing and documenting a TMC's operational procedures promotes: (1) consistent traffic management performance, (2) improved stakeholder relations and (3) quality TMC personnel training with less effort.

A TMC operations manual promotes consistency in activities which, in turn, improves personnel and public safety, enhances agency productivity, reduces agency liability risk and improves customer satisfaction. In addition, consistent and documented operational procedures improve the collaboration and coordination between traffic management stakeholders. Outside agencies, such as law enforcement or local transportation agencies, will more easily work with and involve transportation agency personnel if their roles, capabilities, responsibilities and standard procedures are consistent during each interaction.

Perhaps the most tangible benefit resulting from formalized and documented operational procedures relates to personnel training. As mentioned previously, TMCs may experience high rates of turnover due to lack of a progressive career path or budgetary constraints that limit competitive salary offerings. While development of a TMC operations manual is not anticipated to significantly impact the recruitment or retention of qualified personnel, it will ease the level of effort required for training new personnel. As a primer for new TMC personnel, an operations manual can comprehensively overview the TMC functions and the recommended policies, plans and procedures to be followed.

In addition to training new TMC personnel, a TMC operations guide can be used to "remind" (i.e. retrain) existing TMC personnel of the correct operational policies, plans and procedures to follow. This retraining should occur periodically throughout the life of a TMC to ensure consistency in actions. New policies, plans or procedures adopted by an agency need to be incorporated into the TMC operations manual as they are developed.

In each case, position descriptions contained in the TMC operations manual can be linked to concurrently defined performance objectives to lend focus to actions and to encourage constant improvement in the TMC program.

A third application of a TMC operations manual for personnel training includes awareness training for personnel outside of the transportation

agency. Understanding the roles, duties, and responsibilities of other agencies engenders trust and patience when working together to improve traffic management. In particular, non-transportation personnel should understand the traffic and safety implications of lane or total freeway closure. If the TMC is multi-agency or multi-jurisdictional in structure, the roles, duties and responsibilities of each participating agency can be contained within the TMC operations manual for all personnel to review. If the TMC is operated singularly by a transportation agency, the TMC operations manual can be provided to outside agencies to increase awareness.

3.3.2. Formalized and Documented System Maintenance, Monitoring and Security Procedures

Formalizing and documenting a TMC's system maintenance, monitoring and security procedures as part of a TMC operations manual can ease challenges related to technology evolution and integration and can reduce and improve responsiveness to system failures and false alarms.

The number of technological devices and complexity of the overall TMC system challenges transportation agencies to keep all aspects of the system functional. The problem is further complicated by the fact that today's systems, subsystems, and components are often highly interdependent; a single malfunction can critically impact the ability of the overall systems to perform their intended functions (FHWA 2001). Consequently, transportation agencies must plan for and respond to these expected failures by anticipating and furnishing the resources, capabilities, and services necessary to maintain the systems throughout their productive lives.

3.3.2.1. System Maintenance and Monitoring

System maintenance and monitoring refers to a series of methodical, ongoing activities designed to minimize the occurrence of systemic failures and to mitigate their impacts when failures do occur. The system itself is often the first source of an indication that an element of the system is malfunctioning; most systems perform some type of polling to verify status and capability of each element to which they are connected (FHWA 1999). Maintenance includes the development and implementation of action plans for responding quickly, efficiently, and orderly to systemic failures. It also includes an infrastructure and procedures for measuring and monitoring maintenance activities.

Both automated and manual logging of suspected and verified failures is critical to improving system performance. In the short term, the logged information assists in isolating the fault and effecting repairs or replacement and possibly for obtaining repairs under warranty provisions. In the intermediate term, this information is useful in planning and budgeting for

preventative maintenance including periodic replacement of units with limited service lives. In the longer term, the maintenance history of a device or a class of devices is provides the information which can be used to make purchase decision for an overall upgrade of the system or for expansion for the system (FHWA 1999).

A TMC operations manual should describe both consistent procedures for conducting maintenance activities and for recording maintenance events to achieve wide-reaching benefits in system functionality and agency efficiency.

3.3.2.2. System Security

A variety of approaches exist for ensuring TMC system security, ranging from complex multilevel approaches where each individual is identified to one or more levels within a series of security tiers to simpler schemes where a common system identification and password exist (typically controlled by a supervisor), which is used by all operations (and often other) staff.

Almost all TMC systems provide some form of remote, dial-in access, even if it uses a simpler user interface in recognition of the bandwidth demands of a fully graphic user interface. Since the dial-in capability represents a potential weak point in the total security program, careful planning, and perhaps consultation with a security expert, is warranted. Conversely, creating a burdensome security program that results in dial-in access that is tediously slow and failure prone defeats the purpose of having established the function.

A TMC operations manual helps to ensure that consistent security procedures are followed outside of the automated security features of the system (i.e., changing passwords routinely, shutting computers down during non-operation hours, etc.).

3.3.3. Formalized and Documented Data Collection, Analysis and Warehousing

Documentation is often a forgotten detail during traffic management activities. This is especially problematic with increasing threats of litigation. Nonexistent or poor documentation of traffic management actions can severely reduce a responding agency's or company's defense against litigation. The documentation of a TMC's activities is essential for several other reasons:

- to identify critical locations or time periods for traffic problems
- to evaluate a TMC's effectiveness and demonstrate attributable benefits

- to identify equipment or personnel needs and justify the need for a TMC or TMC expansion
- to effectively communicate and convince administrators and policy makers of the needs.

The benefits from a formalized program of data collection, analysis and documentation, supported through the development of a TMC operations manual, can be significant. Improved documentation of operational activities can better encourage the move from a design/construct to a operate/maintain regime, position operational alternatives to compete better for limited resources in a planning context and can justify continuation of or expansion of existing resource allocations by demonstrating measurable attainment of performance goals and improved customer service.

3.4. Key Issues

As mentioned previously, a TMC operations manual is a tool that agencies are encouraged to develop, maintain, and use in managing and supporting the day-to-day operations and activities performed by a TMC. The specific content of a TMC operations manual will vary based on the structure, operation (i.e. services provided), agency participation and political context of the TMC. In addition, the process for developing and maintaining a TMC operations manual will vary depending on transportation agency resources, priorities, access to outside resources and other constraints.

3.4.1. TMC Operations Manual Development

The development of a TMC operations manual may be motivated by any number of factors, including a priority shift to customer service, an identified need for training and operations support materials, attainment of funding to develop a TMC and support materials, etc. Regardless of the underlying motivation, a successful TMC operations manual development process relies on one thing – a champion. This individual can be employed by a transportation agency, law enforcement agency, or other but must be committed to successfully developing an effective TMC operations manual.

The development itself can occur either internally, using agency staff to gather and assimilate information or an agency can hire an outside contractor/consultant to develop a TMC operations manual specific to their locale. Each alternative has advantages and disadvantages. Developing a TMC operations manual internally benefits from the staff's knowledge regarding agency policies, stakeholders and local conditions but may take longer to develop unless the staff is dedicated to the effort (i.e., temporarily released from other work-related duties). External contractors/consultants can typically provide a completed TMC operations manual in less time despite some initial required effort to become familiar with

local conditions. External contractors/consultants are also often more familiar with national practice, successful practices, lessons, learned, etc. that can be then applied to a specific locale.

Format (i.e., hardcopy or electronic) for the TMC operations manual is another consideration during the development stage. Hardcopy manuals are favored for their ease in access, particularly if the TMC system is experiencing a failure that prevents access to electronic documents. Electronic manuals are favored for their "lookup" or search features when a particular topic is sought and for their ease of update when policies or procedures change.

3.4.2. TMC Operations Manual Content

The specific content of a TMC operations manual can vary widely depending on the nature of the TMC (i.e., single agency vs. multi-agency), its size, the level and complexity or its organizational structure, the functions, services and systems provided, actual and desired levels of inter-agency/inter-jurisdictional coordination, etc.

Guidelines, such as *An Annotated Outline for Traffic Management Center Operations Manuals* (ITE 2001) and this document are intended to provide a consistent outline or framework from which to develop a TMC operations manual, variability in content is left to the most detailed discussion contained in the TMC operations manual.

3.4.3. TMC Operations Manual Maintenance

Maintaining a TMC operations manual largely includes updating contact lists and/or rosters as personnel changes occur and modifying policies or procedures as needed. Keeping contact lists and/or rosters up to date can be time consuming and difficult if regular communications among agencies or jurisdictions do not make such changes readily apparent. TMCs may implement periodic "requests for update" to be distributed to other agencies and jurisdictions involved with the TMC to try to better capture these personnel changes. Updates regarding modified policies and procedures are easier to identify, agencies should make a regular practice of updating the TMC operations manual upon notification to keep the information current. Agencies may need to allocate staff resources to this effort to ensure timely completion.

Additionally, agencies should implement tracking methods to help ensure that the information contained in a TMC operations manual, is the most current and accurate with respect to agency policies and procedures. Including a date stamp somewhere on the modified document is the simplest way track changes.

3.5. Concept of Operations and Requirements for a TMC Operations Manual

The Institute of Transportation Engineers (2001) recommends the following content for a TMC operations manual:

- emergency and other contact numbers
- daily operation including management center functions; personnel, staffing and hours of operation; after-hours, remote operation and security procedures (i.e., access to control system interfaces); maintenance, startup/shutdown and failure recovery (automated and manual) procedures; and notification procedures
- control system operation including operator interface, operational procedures (i.e., manual, automated, demand responsive, default) and incident management procedures
- maintenance procedures including routine, preventative, emergency (non-routine) and contract maintenance and the location of spare/backup equipment
- system operations logs including operations, maintenance, events, system reports and traffic data and risk management (i.e., what to keep, log, save or discard)
- operational concepts including traffic monitoring, data analysis and warehousing, interagency coordination, inter-jurisdictional coordination and emergency procedures (i.e., notification, monitoring and coordination)
- control center /system field device descriptions including location, access/security, layout, fire suppression, power source/location, HV/AC and data, voice and network communications
- system documentation including vendor maintenance documentation.

This information may be organized in multiple documents (i.e., a TMC operations manual and a TMC maintenance manual); this effort assumes that the information will be contained in a single TMC operations manual.

A TMC concept of operations document, that provides a general overview of TMC functionality prior to the design stage, contains many of the same categories of information recommended for inclusion in the TMC operations manual. The primary distinction between the two documents is the level of detail contained. The operations manual defines step-by-step how to perform each activity and provides specific contact names and numbers for the various interfaces; the concept of operations defines generically who should be contacted. Nonetheless, the TMC concept of operations provides a good framework for the development of a TMC operations manual. This section details the content of a TMC concept of operations

and describes how it can be used to support development of a TMC operations guide. It is assumed that a TMC concept of operations document has been previously developed specific on one's locale; if no such document exists, the *Traffic Management Center Concept of Operations Implementation Guide* (FHWA 1999) provides a good, albeit general, reference for TMC operations manual development.

3.5.1. What is a Concept of Operations?

In general, a TMC concept of operations defines what the center accomplishes (i.e., functions), and how it goes about accomplishing it (i.e., procedures). The concept of operations addresses both operations and maintenance of the TMC, and the resources for which it is responsible. It describes the interactions that occur within the TMC, and between the TMC and its partners (firms and agencies) and customers (motorists, media, etc.) in managing transportation (FHWA 1999). At a summary level, a TMC concept of operations could contain the following topics:

1. BACKGROUND
   - 1.1. Need, Purpose and Concept for the System
   - 1.2. Mission, Vision, Goals and Objectives

2. SYSTEM DESIGN AND IMPLEMENTATION
   - 2.1. General System Design Parameters
   - 2.2. Level and Type of Automation
   - 2.3. General Systems Functions Performed/Provided
   - 2.4. System Devices and Interoperation
   - 2.5. System Implementation
   - 2.6. System Testing
   - 2.7. System Training and Documentation

3. SYSTEM OPERATIONS
   - 3.1. Workload and Performance
   - 3.2. Coordination
   - 3.3. Conflict Resolution
   - 3.4. Nonstandard Operation
   - 3.5. Fault Detection and Correction

4. SYSTEM MAINTENANCE
   - 4.1. Configuration Management
   - 4.2. Logistics
   - 4.3. Maintenance
   - 4.4. Operations Simulation

3.5.2. Using a TMC Concept of Operations Framework to Develop a TMC Operations Manual

To: (1) ensure consistency with local, regional and statewide goals and previously developed guidance documents, (2) best reflect the existing and planned capabilities of the TMC and (3) make the most efficient use of agency resources, personnel can utilize information contained in a TMC concept of operations to "jumpstart" development of a TMC operations manual with the understanding the supplemental detailed information will be required for completion. Using state-of-the-practice recommendations regarding document content, Table X depicts the mapping of TMC concept of operations information to the TMC operations manual.

1 Emergency and Other Contact Numbers

One of the first recommended items for inclusion in a TMC operations manual is a phone list of emergency agencies, support agencies and personnel that may be called for assistance and coordination. These could include: police, fire, courtesy patrol vehicles, transit, emergency maintenance operations (for freeways, streets, bridges and pump houses), street operations, 911 PSAP operations, towing services and operational personnel contact information (including home phones, cell phones, pagers and email). In regions characterized by a large number of jurisdictions, supplemental maps illustrating the physical boundaries for agency responsibilities could be included.

A TMC concept of operations will not contain the level of detail required to complete this information. Section *3.2 Coordination* in the concept of operations document may, however, offer some direction as to the agencies (emergency and support) that should be represented on this contact list. This section describes the roles and responsibilities of the participating agencies and interactions between TMC personnel and external agencies.

Using the information contained in the TMC concept of operations to guide general content (i.e., agency inclusion), transportation agencies can supplement with specific contact names and numbers for each of the entries.

2 Daily Operation

Recommended TMC operations manual content to describe daily operations can be categorized as:

the functions performed by the TMC,

personnel including an organization chart and job descriptions and hours of operation and staffing including workdays, holidays, special events and emergencies

an after hours, on-call roster, remote operating and security procedures including access to control system interfaces, equipment, etc.

Table X. Mapping TMC Concept of Operations Information to a TMC Operations Manual

TMC OPERATIONS MANUAL	TMC CONCEPT OF OPERATIONS
1 Emergency and Other Contact Numbers	3.2 Coordination
2 Daily Operation	
2.1 Management Center Functions	2.3 General System Functions Performed/Provided
2.2 Personnel	2.1 General System Design Parameters 3.1 Workload and Performance 3.3 Conflict Resolution
2.3 Hours of Operation	2.1 General System Design Parameters 3.1 Workload and Performance
2.4 Staffing	2.1 General System Design Parameters
2.5 After-Hours, On-Call Roster	3.2 Coordination
2.6 Remote Operation	2.4 System Devices and Interoperation 3.1 Workload and Performance
2.7 Security Procedures	2.4 System Devices and Interoperation
2.8 Maintenance Checklist	3.5 Fault Detection and Correction
2.9 Startup/Shutdown	4.3 Maintenance
2.10 Failure Recovery	4.3 Maintenance
2.11 Agency/Jurisdictional Contacts	2.5 System Implementation 3.2 Coordination
2.12 Notification Procedures	2.5 System Implementation
2.13 Contact with Media	2.5 System Implementation
3 Control System Operation Procedures	
3.1 Operator Interface	2.2 Level and Type of Automation 2.5 System Implementation
3.2 Operational Procedures	2.5 System Implementation
3.3 Incident Management	2.5 System Implementation 3.4 Nonstandard Operation
4 Maintenance Procedures	
4.1 Routine Maintenance	4.3 Maintenance
4.2 Preventative Maintenance	4.3 Maintenance
4.3 Spare/Backup Equipment	4.2 Logistics
4.4 Emergency	3.4 Nonstandard Operation
4.5 Contract Maintenance	4.2 Logistics 4.3 Maintenance

Table X. Mapping TMC Concept of Operations Information to a TMC Operations Manual (Cont.)

TMC OPERATIONS MANUAL	TMC CONCEPT OF OPERATIONS
5 System Operations Logs	
5.1 Operations	N/A
5.2 Maintenance	N/A
5.3 Events	N/A
5.4 System Reports	N/A
5.5 Traffic Data	N/A
5.6 Risk Management	N/A
6 Operational Concepts	
6.1 Traffic Control Concept Strategy	1.1 Need, Purpose and Concept for the System 1.2 Mission, Vision, Goals and Objectives 2.4 System Devices and Interoperation 2.5 System Implementation 3.2 Coordination 3.4 Nonstandard Operation
6.2 Traffic Monitoring	2.1 General System Design Parameters 2.2 Level and Type of Automation
6.3 Data Analysis and Warehousing	3.1 Workload and Performance
6.4 Interagency Coordination	2.5 System Implementation 3.2 Coordination
6.5 Inter-Jurisdictional Coordination	2.5 System Implementation 3.2 Coordination
6.6 Emergency Procedures	2.5 System Implementation 3.4 Nonstandard Operation
7 Control Center Description/System Field Devices	
7.1 Location	2.1 General System Design Parameters
7.2 Access/Security	2.1 General System Design Parameters 2.4 System Devices and Interoperation
7.3 Layout	2.1 General System Design Parameters
7.4 Fire Suppression	2.1 General System Design Parameters
7.5 Power Source/Location	2.1 General System Design Parameters
7.6 HV/AC	2.1 General System Design Parameters
7.7 Data Communications	2.4 System Devices and Interoperation
7.8 Voice Communications	2.4 System Devices and Interoperation
7.9 Network Communications	2.4 System Devices and Interoperation
7.10 Field Device Descriptions	2.4 System Devices and Interoperation
8 System Documentation	4.1 Configuration Management 4.3 Maintenance

routine maintenance checks for office and/or field equipment operation and procedures for startup, shutdown and automated and manual failure recovery

agency/jurisdictional contacts and notification procedures, including the media.

TMC Functions. Section *2.3 General System Functions Performed/Provided* in a TMC concept of operations document will summarize primary and secondary functions of the TMC. General system functional requirements focus on the responsibilities of the TMC personnel; the center however may support transportation management operations in a multi-agency, multi-modal environment. Little additional detail may be required to complete this section of the TMC operations manual.

Personnel, Hours of Operation and Staffing. Sections *3.1 Workload and Performance* and *3.3 Conflict Resolution* in a TMC concept of operations document will provide a personnel organization chart, brief descriptions of the roles and responsibilities of key staff positions and methods for resolving conflicts among personnel. A TMC concept of operations may include the following staff positions:

TMC Manager - The TMC Manager will provide ultimate oversight of TMC operations. The TMC Manager will respond to inquiries from higher levels of agency management and/or from external sources regarding general TMC performance or the management of a large-scale incident. In certain situations, it may also be appropriate (or agency policy) to involve or work through the agency's public affairs office. The TMC Manager's office should be adjacent to the control room for convenient access.

Operations Supervisor - The Operations Supervisor will provide "hands-on" management of the day-to-day operations for the TMC. Specifically, the Operations Supervisor will be responsible for managing and scheduling the operations staff; providing training of the operators; assisting operators during periods of high activity or staff shortages; assigning staff authorization to control subsystems; assisting in identifying problems and determining times for preventive/corrective maintenance; and developing procedures dealing with planned and unplanned events. The Operations Supervisor will resolve disputes pertaining to TMC operation. The Operations Supervisor will carry a cell phone whenever off-site or elsewhere in the building complex.

Operator - Operators will monitor and control the field devices from the TMC facility. Operators will also be responsible for responding to public inquiries regarding traffic conditions and notifying appropriate agencies

when an incident occurs. Operators will distribute traveler information through the HAR, website and other means (e.g., 511 system). They will evaluate and package data into useful, timely and accurate traveler information. Operators will report to the Operations Supervisor.

Maintenance Supervisor – The Maintenance Supervisor will be responsible for maintenance of the TMC. This position will troubleshoot both control center and field equipment and will work directly with the Maintenance Office to coordinate maintenance crews to repair electronic equipment used in traffic control devices, CCTV systems, and communications systems. This position will also be responsible for documentation of changes made to any component in the system through maintenance or construction operations. This position will report directly to the TMC Manager.

Electrical Technician – The Electronic Technician will be responsible for troubleshooting and repairing electronic equipment used in traffic control devices, CCTV systems, and the communications systems. This position will also be responsible for documentation of changes made to any component in the system through maintenance or construction operations. This position will report directly to the Maintenance Supervisor.

Systems Technician – The Systems Technician will be responsible for maintaining current and/or consistent computer operating systems on all computer equipment; installing hardware and software upgrades; troubleshooting and repairing equipment malfunctions; maintaining computer communication links with TMC partners; and maintaining database and data files for all TMC activity. The Systems Technician will report to the Maintenance Supervisor (FHWA 1999).

The TMC operations guide can enhance the level of detail provided here to identify particular individuals that occupy each position and unique protocols for interactions.

In certain instances, conflicts among staff may arise that require resolution either with or without supervisory intervention. Section *3.3 Conflict Resolution* in a TMC concept of operations may provide useful guidance in developing conflict resolution procedures. Recommendations include using a combination of manual and automated recordkeeping to effectively document the situation, communications, actions taken, and approvals and defining a clear chain of command for decision-making (i.e., authority passes from the Operator to the Operations Manager to the TMC Manager). The TMC operations manual should additionally detail how to access key decision-makers (i.e., by telephone, cellular phone, and pager).

More general information pertaining to the hours of TMC operations and its general staffing plan may be sufficiently detailed in *2.1 General System*

Design Parameters of a TMC concept of operations document. This section will generally describe the days and hours of normal TMC operation; contingent TMC operation during construction, special events or incidents/emergencies; operator overlap during peak periods or shift changes; staff rotations for on-call operations, etc. Little additional detail may be required to complete this section of the TMC operations manual.

After Hours, On-call, Remote Operation and Security Procedures. As when developing *1. Emergency and Other Contact Numbers*, a TMC concept of operations will not contain the level of detail required to complete a roster of after-hours, on-call personnel. Again, *Section 3.2 Coordination* in the concept of operations document may, however, offer some direction as to the agencies (emergency and support) that should be represented on this roster. This section describes the roles and responsibilities of the participating agencies and interactions between TMC personnel and external agencies.

The set of individuals contained on the after-hours, on-call roster will likely differ than those contained on the emergency and other contact numbers list, although some duplication is anticipated. Using the information contained in the TMC concept of operations to guide general content (i.e., agency inclusion), transportation agencies can supplement with specific contact names and numbers for each of the entries.

Remote operation and security procedures will be generally defined in *Section 2.4 System Devices and Interoperation* in a TMC concept of operations document. Typically, a TMC system will allow operators to monitor and control the TMC field devices through workstation consoles and various hardware and software subsystems, either on-site or remotely using dial-up capabilities. Each workstation will have access to all field devices, but control of these devices may be assigned to operators through user ID and a network firewall to protect against unauthorized local and remote access. This section will generally define priority and secondary control for each of the various TMC components.

Supplemental detail, including the agency responsible for each action, how agencies share access to common resources and what agencies can perform critical actions under nonstandard circumstances (i.e., emergency operations or shortage of essential staff) is required to complete the TMC operations manual.

Maintenance and Startup, Shutdown and Failure Recovery Procedures. Sections *3.5. Fault Detection and Correction* and *4.3 Maintenance* in a TMC concept of operations document provide a good basis for developing a maintenance checklist and startup/shutdown and failure recovery procedures.

A TMC concept of operations may recommend the following general areas to consider:

- access control - who controls the system privileges, how may levels are maintained, how often passwords change?
- network management - what network management tool is used, what performance parameters are monitored?
- backups - when are they performed, to what media, where they are retained and how long, how quickly can restorations be made, whether they are partial or complete, whether real-time backup is achieved through mirroring?
- materials and supplies - who can distribute the supplies, who controls purchasing them, what quality standards are established?
- upgrades and bug fixes - how quickly after release these are implemented, by whom, how they are tested with the custom applications?
- troubleshooting - what training and tools are acquired, what arrangements are made for expert assistance?
- monitoring system performance - what performance parameters are monitored, what thresholds are established, can high load simulations be conducted, how are impact assessments made, what program of ongoing fine-tuning is implemented
- user support - how do users (particularly non-prime shift users) contact the system maintenance team, what level of responsiveness is desired, what kinds of things users are responsible for doing themselves?
- participating in testing and system acceptance - how does system management participate in planning, executing, witnessing and defining acceptability tests
- participating in training - how does system management participate in training for non-systems elements of the system? (FHWA 1999).

Transportation agencies can pursue answers to the questions posed as part of these general considerations when developing the TMC operations guide. This approach will help to ensure a sufficient level of detail.

Sufficient detail is also required when describing communications requirements for maintenance events among affected parties. A TMC concept of operations document, section *4.3 Maintenance,* will provide a general description of required communications links between:

- maintenance and operations personnel to report either a maintenance activity or a need

- maintenance and/or operations and other affected departments within the agency (i.e., illumination and signal departments for signal, flasher, or illumination failures
- maintenance and equipment vendor/supplies and
- maintenance personnel and a centralized maintenance database used in tracking equipment status and reliability

and times:

- at the beginning of a shift, to determine what maintenance is planned, what the impact will be and what actions are required
- at the beginning of a task, to indicate that a change in status is taking place, the potential for danger to personnel exists and support may be required
- when the task is done to indicate that the device can be returned to the appropriate operational status and the potential for harm to maintenance personnel has been terminated and
- at shift completion, to determine accomplishments during the period, plans for additional action if required and any changes in status of devices (FHWA 1999).

The TMC operations manual should detail the points of contact for each exchange (i.e., individual names and contact information) and a format for consistent information exchange.

Agency/Jurisdictional Contacts, Notification Procedures, Contact with the Media. A TMC concept of operations will not contain the level of detail required to complete this information. Section *3.2 Coordination* in the concept of operations document may, however, offer some direction as to the agencies and jurisdictions that should be represented as contacts and appropriate notification procedures. For each type of interaction, the following information should be recorded to support development of a TMC operations manual:

- the circumstances that bring about interaction
- between whom the interactions take place (i.e., which organization and at which levels)
- how it takes place (voice, telephone, radio, fax, email)
- what the interaction contains (what information, what request)
- how each party responds to the interaction (information, action, request for additional information or support)
- how the interaction continues or resumes (monitoring and reporting of status of causative situation, thresholds for additional action)

- what triggers termination of the interaction (return to baseline conditions)
- how the interaction is documented
- how the termination is confirmed (FHWA 1999).

Using the information contained in the TMC concept of operations to guide general content (i.e., agency and jurisdiction inclusion, interactions), transportation agencies can supplement with specific contacts for each of the entries and work with participating agencies/jurisdictions to develop specific and mutually acceptable notification procedures. Content related to contact with the media is best obtained through the agency's Public Information Office, who can provide valuable guidance in working with the media and will be aware of any agency policies governing media relations. The TMC operations manual should have consistent media relations policies as the larger transportation agency.

3 Control System Operation Procedures

As part of a TMC operations manual, control system operation procedures detail the day-to-day electronic hardware and software system operation (i.e., enter text, zoom, change view, save record, etc.). Procedures for manual, automated, traffic responsive, free and default operation, as well as operation during non-routine occurrences (i.e., incidents) should be included. These procedures will be governed by existing transportation agency policies and procedures.

Sections *2.5. System Implementation*, *2.2 Level and Type of Automation* and *3.4 Nonstandard Operations* in a TMC concept of operations document will provide general information related to the process of monitoring traffic and detecting problems, initiating advisories and providing periodic status reports and an estimate for return to normal operations, altering the operations of roadways (i.e., adjusting signal timing to accommodate the unusual traffic patterns or posting messages on the DMS), exchanging data within and outside the agency and automatically and manually logging information and actions.

For the level of specificity required, the transportation agency may better rely upon documentation furnished by system suppliers (i.e., hardware and software vendors) to fully develop the TMC operations manual.

4 Maintenance Procedures

Maintenance procedures, as documented in a TMC operations manual, should address: (1) routine maintenance, including typical daily checks, adjustments and minor component replacement; (2) scheduled preventative maintenance performed by the agency or vendor, (3) an inventory of

spare and backup equipment including a listing of suppliers, vendors and contractors associated with equipment and software and their contact information, (4) emergency (i.e., non-routine) maintenance and (5) contract maintenance including the procedures or warrants by which a private maintenance contractor would be requested.

TMC maintenance procedures include traditional activities (i.e., replacing bulbs, replenishing lubricants, cleaning lenses) for TMC system components, as well as computer software and hardware maintenance. Software maintenance includes ongoing debugging, testing and implementation of operating systems, commercial software upgrades; additional protocols and device interfaces for new equipment, additional or modified algorithms, etc. Hardware maintenance typically includes standard maintenance activities and a planned replacement program to prevent obsolescence. Acquiring replacement parts or contract maintenance service on units which have been out of production for more than a year or two is challenging (FHWA 1999). Updates to system and user documentation, training materials and software configuration materials are required along with most computer maintenance activities.

Sections *4.3 Maintenance* and *3.4 Nonstandard Operation* in a TMC concept of operations document will describe general procedures for and recommendations to facilitate TMC maintenance activities including:

- procure initial spares, tools, and test equipment through TMC installation contracts
- specify a reasonable duration (i.e., two years after acceptance) for installation contractors to provide equipment support
- for system expansions, specify that warranties, managed by the system support contractor, begin at system acceptance
- identify other agencies, located nearby and who own identical equipment, who may provide spares on short notice outside the normal agency procurement process
- investigate ability to download software patches from dial-up or internet connections and
- specify response times for equipment or services in any maintenance or support contract (i.e., rapid response support contract) (FHWA 1999).
- A TMC concept of operations will also provide general guidance for performing emergency maintenance activities and operating with partial system functionality until the problem is remedied. During such times, a TMC will likely be provided with uninterruptible power supplies and backup generators. A failure will most likely result from the failure of a specific piece of critical equipment such as a server, switch

or primary multiplexer (Kimley Horn and Associates, Inc. and ConSysTec Corporation 2004). The process for addressing this condition may include:

- identifying and confirming the failure, determining what has failed, and getting work underway to remedy the situation
- understanding the impact of failure and determining what types of "workarounds" are available. (i.e., backup systems, use of alternate or remote workstations, use of temporary portable devices, dial-up instead of direct connections, movement of personnel to the field to access the assets directly, etc.)
- communicating to the appropriate parties the impact in order to manage expectations, this may include getting information to the public if the failure will be noticed (Kimley Horn and Associates, Inc. and ConSysTec Corporation 2004).

A TMC concept of operations document will also generally describe and recommend a program of maintenance monitoring to support warranty claims and improved design and operation decisions. Using maintenance records, which may be in hard copy form or electronic, will be eventually recorded in a central maintenance management database, maintenance personnel at the TMC may record and perform the following types of analysis:

- mean time between failures (i.e., the performance of device, reliability)
- extent and type of required repairs and mean time to repair
- effort and resources necessary to maintain certain devices or types of devices, including manpower, consumables and tools, test equipment, and support equipment.

Despite the useful guidance provided through a TMC concept of operations, maintenance procedures described in the TMC operations manual will be based largely on documentation furnished by system suppliers. These outside references will contain sufficient detail and guidance to support maintenance of on-site and field components.

5 System Operations Logs

Included as part of a TMC operations manual, system operations logs to document system operation may include operation periods (i.e., on-line/off-line periods, manual overrides, etc.), maintenance activities (i.e., outages, resolution of problems, etc.) events such as planned and unplanned incidents, system operation evaluation parameters, etc., traffic data to support historical trends, data analyses, etc. and guidance to opera-

tors of what to keep, log, save, or discard in response to the agency's risk-management policies.

A TMC concept of operations will not contain the type of information or level of detail required to complete this information. Automatic logging features are most often incorporated into system software applications. Hence, the transportation agency may better rely upon documentation furnished by system suppliers (i.e., hardware and software vendors) to describe logging features and capabilities; TMC managers can then decide what information and at what frequency system operation logs will be made. This information should be documented in the TMC operations manual.

6 Operational Concepts

In developing *6. Operational Concepts* of a TMC operations manual, transportation agencies should ask:

- what is our role in the regional transportation community and how do we approach delivery of services? (i.e., traffic control concept strategy)
- physically, how do we monitor traffic/transportation here? (i.e., traffic monitoring)
- how do we work with our internal partners and our regional partners? (i.e., interagency and inter-jurisdiction cooperation)
- What are our emergency procedures related to notification, monitoring and coordination?

If previously developed, a TMC concept of operations document will directly address these questions, both in content and level of detail. The following sections from a TMC concept of operations are most applicable:

1.1 Need, Purpose and Concept for the System – describes the overall motivation for TMC development (i.e., in response to recurring traffic congestion, mobility constraints, air quality, safety, regional travel, etc.) and broadly overviews its intended functions (i.e., to support functions related to transit operations, emergency management, maintenance and construction, commercial vehicle operations and border activities, etc.).

1.2 Mission, Vision, Goals and Objectives – based on the motivation for development, defines responsive goals and objectives for TMC functionality.

2.4 System Devices and Interoperation – describes the various system devices (i.e., communications and components) used singularly or in combi-

nation to achieve the aforementioned TMC functionality goals and objectives.

2.1 General System Design Parameters – describes, with more specificity, the TMC's various system devices (i.e., communications and components) used to support traffic monitoring and other activities.

2.2 Level and Type of Automation – indicates the level of automation that will be available to TMC operators to conduct traffic monitoring and other activities, as well as system and performance monitoring.

3.1 Workload and Performance – dependent on the level and type of automation, describes performance monitoring in terms of both the system performance (equipment hardware and software) and the personnel performance in delivering expected TMC functions.

3.2 Coordination - describes each of the functions to be performed within the TMC, roles and responsibilities of the participating agencies and the processes the staff will follow in performance of their duties, including interactions between the staff and between staff and external organizations.

2.5 System Implementation – describes the system implementation strategy including integration of multiple traffic operations centers within the same agency (i.e., multiple state transportation agency TMCs) or with other agencies; includes methods for notification, followup and data exchange.

3.4 Nonstandard Operations – describes general procedures for nonstandard operations including emergency operations.

> Given the comprehensive related content contained in a TMC concept of operations document, little additional detail may be required to complete this section of the TMC operations manual.

7 Control Center Description/System Field Devices

In a TMC operations manual, recommended content for *7 Control Center Description/System Field Devices* includes a plan view of the center layout, a description of the location and characteristics of the building (i.e., security, access to buildings, access to control rooms, guard duty schedules, etc.) and a description of controls, cutoffs, operation, etc. for various critical infrastructure components including fire suppression equipment, power sources, and HV/AC systems. Also recommended for inclusion is a description of data, voice and network communications systems including the terminals, equipment location, etc. for landline instruments (i.e., location, numbers, extensions, terminals, policies, etc.), radio communications (i.e., unit locations, call signs, policies, etc.) and local area and wide area networks. An identification of the databases where current descriptions of

all field devices are maintained, including the locations where any passwords are kept is contained here as well.

Sections *2.1 General System Design Parameters* and *2.4 System Devices and Interoperations* in a TMC concept of operations document may provide a useful framework for completing this information. These sections in a TMC concept of operations generally describe the location and characteristics of the TMC building and system components including access and control.

Using the information contained in the TMC concept of operations to guide general content (i.e., building features, communication mediums, field devices, etc.), transportation agencies can supplement with greater detail (i.e., password locations, etc.) to complete the TMC operations manual.

8 System Documentation

Related to *4. Maintenance Procedures*, *8. System Documentation* includes vendor maintenance documentation and procedures for securing documentation revisions and updating maintenance document bibliographies.

Sections *4.1 Configuration Management* and *4.3 Maintenance* in a TMC concept of operations document provide general recommendations for establishing and maintaining an accurate and complete configuration database for all elements of the TMC and field hardware and software (and potentially vendor provided services such as communications) and for monitoring maintenance-related performance.

Despite the useful guidance provided through a TMC concept of operations, however, system documentation, as described in the TMC operations manual, will be based largely comprised of documentation furnished by system suppliers. These outside references will contain sufficient detail and guidance to support maintenance of on-site and field components.

3.6. Successful Practices

As described previously, potential benefits resulting from the development and use of a TMC operations manual relate to formalized and documented: (1) operational procedures that will, in turn, lend consistency to day-to-day activities, improve inter-agency and inter-jurisdictional working relationships and ease internal training efforts; (2) system maintenance, monitoring and security procedures that will improve resource utilization and enhance system safety; and (3) data collection, analysis and warehousing procedures that will support short- to long-term facility performance improvements and planning efforts.

Reviews of existing TMCs around the Nation revealed several successful practices and programs that reinforce the wide-ranging need, importance and value of a TMC operations manual. This section highlights key findings; a more detailed review is provided in *7. Case Studies* later in this document.

3.6.1. Using a TMC Concept of Operations Framework to Develop a TMC Operations Manual

None of the TMCs considered had developed a concept of operations per se before the TMC was implemented, although most had conducted planning before implementing their systems. Interviewees from TMCs that conducted thorough planning confirmed that the sense of direction gained by documenting the TMC's understood mission, vision, goals, and objectives made center operations much easier (FHWA 1999).

3.6.2. Using a TMC Operations Manual to Support Operational Procedures

Several TMCs have developed and refined their operations procedures; however, evidence of a comprehensive TMC operations manual to document these procedures was rare. Most TMCs offer limited documentation to support operations and supplemented this information with outside references. The most complete TMC operations manual examples were uncovered for Arizona's TrailMaster TMC in Phoenix, Tennessee's Region 3 Transportation Management Center (TMC) in Nashville and Toronto's COMPASS Downsview TMC (FHWA 1999).

3.6.2.1. Arizona's TrailMaster TMC in Phoenix

Arizona's TMC operations manual content is provided in Table X. This reference is supplemented with a systems users manual, plans and specifications, a functional decomposition, construction equipment submittals, "before" and "after" evaluation subsystem design documents and a two-volume software design. The TMC operations manual will be used to support new hire training, which is primarily on the job, supervised by senior operators and the operations supervisor (FHWA 1999).

Table X. Arizona Department of Transportation TMC Operations Manual (ADOT 2003)

1. INTRODUCTION

1.1 Manual Updates

1.2 TOC Functions

1.2.1 Incident Management Function

1.2.2 Traffic Management Function

Appendix G: FMS Implementation Block Diagram

Appendix H: VMS Information

Appendix I: Troubleshooting

3.6.2.2. Tennessee's Region 3 Transportation Management Center (TMC) in Nashville

The Tennessee Department of Transportation recently developed document comprising a high-level gathering of operational policies that have been created and approved by the Tennessee Department of Transportation (TDOT) for the TDOT, Region 3 Transportation Management Center (TMC) serving the Nashville Metropolitan Area. The policies are divided into functional area/grouping (TDOT 2002).

This manual deals with global agency policy; more specific operational details can be found in outside references, such as the MIST™ User's Manual, that contain specific Operational Procedures for daily operations, control of specific devices, etc. (TDOT 2002)

Since policies may change over time, the individual policies have been numbered for tracking purposes; TDOT will initiate regular Policy Manual and Operations Manual update cycles (quarterly or as directed by TDOT) to review and updates as required. The operations manager acting under the direction of the TMC manager is responsible for making and monitoring the updates (TDOT 2002).

3.6.2.3. Toronto's COMPASS Downsview TMC

Operators at Toronto's COMPASS Downsview TMC are provided an operations procedures manual that contains information on:

- system purpose, background, objective, and overview
- job descriptions, conduct, security, shift start and end procedures
- changeable message sign operation and policy, incident detection
- closed circuit television cameras and taping
- detector placement, use of computer terminals and Road Weather Information System
- TRIS (traveler and road information system) policy
- driver and vehicle terminal, communications, and incident management protocols
- media, general public, Ontario Provincial Police liaison, and liaison with other COMPASS and Ministry of Transportation Ontario staff

- radio system protocol, hardware failures procedures, phone directory, and use of operational documents (FHWA 1999).

Other documents provided to TMC operators include:

- a patrol list providing patrol coverage and methods of contact

Table X. Tennessee Department of Transportation TMC Operations Manual (TDOT 2002)

1 INTRODUCTION	5 CONTROL SYSTEM OPERATION POLICIES	8.2.6 Display of Upcoming Special Events that Adversely Affect Travel
2 EMERGENCY/OTHER CONTACT NUMBERS	5.1 Operator Interface	8.2.7 Display of Travel Times
3 GENERAL POLICIES	5.2 Operational Procedures	8.2.8 Traffic Diversion (General)
3.1 Update Status and Record	5.3 Incident Management	8.2.9 Traffic Diversion (Full Highway Closure)
3.2 Change Policy	5.3.1 Incident Classification Policy	8.2.10 Traffic Diversion to Roadways Not Under the Jurisdiction of TDOT
3.3 Visitor and Tour Policy	5.3.2 Incident Response	8.2.11 DMS Messages for Adverse Weather, Environmental, and Roadway Conditions
3.4 ATMS Hardware and Software	5.3.3 Incident Detours	8.2.12 Limits of DMS Influence for Incidents
3.4.1 General Equipment	5.3.4 Incident Information	8.2.13 DMS Message Priority
3.4.2 Operator Specific Equipment	5.3.5 Incident Tracking	8.2.14 Other DMS
3.4.3 General TMC Property	5.3.6 Data Entry	8.2.15 DMS Message Confirmation
3.4.4 Telephone and Fax Usage	5.3.7 Incident Paging and Call-Out	8.2.16 Use of Highway Advisory Radio (HAR)
3.5 TMC Cleaning and Maintenance	5.3.8 Post Incident De-briefs	8.2.17 HAR Messages
3.6 Pass Keys and Controlled Access	6 MAINTENANCE POLICY	8.2.18 HAR Message Format
3.7 MIST™ Software	6.1 Routine Maintenance	8.2.19 HAR Message Confirmation
3.8 Building Security and Parking	6.2 Preventative Maintenance	8.3 Miscellaneous Concepts and Policy
3.9 Staff Meetings	6.3 Spare/Backup Equipment	8.3.1 Media/Interagency Image Requests
3.10 Smoking Policy	6.4 Emergency	8.3.2 Web Site Images
3.11 Uniform and Dress Code	6.5 Contract Maintenance	8.3.3 DMS for Special Events
3.12 Drug-Free Workplace	7 SYSTEM OPERATION LOGS	8.3.4 DMS Regulatory Speed Messages
3.13 Breaks and Lunch	7.1 Operations	8.3.5 Advertising
3.14 Work Shifts, Organization Chart and Training	7.2 Maintenance	8.3.6 Public Service Announcements
3.15 Incident Command System	7.3 Events	8.3.7 Display of Amber Alerts
3.16 Homeland Security	7.4 System Reports	8.3.8 Intermodal Information
3.17 Severe Weather Conditions	7.5 Traffic Data	8.3.9 DMS Test Messages
4 DAILY OPERATION	7.6 Risk Management	8.3.10 Ramp Metering
4.1 Management Center Functions	8 OPERATIONAL CONCEPTS	8.4 Data Analysis And Warehousing
4.2 Personnel	8.1 Traffic Monitoring	8.5 Interagency and Inter- Jurisdictional Coordination
4.3 Hours of Operation	8.1.1 Speed Detector Monitoring and Response	9 CONTROL CENTER DESCRIPTION/SYSTEM FIELD DEVICES
4.4 Staffing	8.1.2 CCTV Image Viewing	9.1 Location
4.5 After Hours On-Call Roster	8.1.3 Video Wall	9.2 Access/Security
4.6 Remote Operation	8.1.4 Video Sequences	9.3 Layout
4.7 Security Policy	8.1.5 Recording Video Images	9.4 Fire Suppression
4.8 Maintenance Checklist	8.1.6 Road Construction Monitoring	9.5 Power Source/Location
4.9 Startup/Shutdown	8.1.7 Road Construction Reporting	9.6 HV/AC
4.10 Failure Recovery	8.1.8 Diversion Route Planning	9.7 Data Communications
4.11 Agency/Jurisdictional Contacts	8.1.9 Highway Maintenance Activity	9.8 Voice Communications
4.12 Telephone Call Etiquette and Notification Policy	8.2 Traffic Response	9.9 Network Communications
4.13 Contact with Media and the Public	8.2.1 Use of Dynamic Message Signs (DMS)	9.10 Field Device Descriptions
4.14 Coordination with HELP Program	8.2.2 Operation of DMS by Law Enforcement Personnel	10 SYSTEM DOCUMENTATION
4.15 Dispatch of HELP Vehicles	8.2.3 Blank Signs	
	8.2.4 Messages during Peak Periods	
	8.2.5 Display of Upcoming Roadwork	

- a technical and electrical binder listing applicable personnel, methods of contact, and Ministry of Transportation Ontario signal locations
- a nuclear emergency/provincial emergency manual
- drawings of equipment locations and IDs
- emergency telephone numbers
- construction contract listings of projects and contacts
- a driver and vehicle binder providing numbers for Ministry of Transportation of Ontario Commercial Vehicle Operations staff
- a service crew binder providing maintenance contacts and emergency operator contacts, including emergency services, automobile clubs, and road agencies (FHWA 1999).

To support and encourage the use of the TMC operations manual, Toronto has reorganized its operations department to include an individual assigned to maintain and update its procedures (FHWA 1999).

Several other TMCs, including Atlanta's NaviGAtor, Boston's Integrated Project Control System (IPCS), Houston's TranStar and Milwaukee's MONITOR, provide more limited examples of good practices related to TMC operation manual development and maintenance:

Atlanta has established a training unit in its planning department, which prepares operations procedures. New operators begin with a 2-week formal training program on the operator console and software and progress to 3 to 4 days each of training on various duties, procedures, and response plans. New hires are provided tours of the project area to gain familiarity with the road network and device locations. They also ride with the motorist assistance patrol during their new hire training (FHWA 1999).

Boston—due to the constantly changing condition of its road network because of the construction of the Central Artery/Tunnel—has a program of continually updating its procedures. Because of the frequent change of its procedures, Boston has implemented desktop rehearsal and new and altered procedure simulations to ensure operational readiness (FHWA 1999).

In Houston, memoranda outline operator roles and responsibilities. Operational procedures are developed on an as-needed basis. New procedures are prepared as new organizational units move to the control room (FHWA 1999).

Milwaukee recognized the need for a different orientation in the training of its law enforcement partner and has developed a customized training manual for its use. Milwaukee has provided a system workstation at the

law enforcement dispatch site and has received positive feedback from the law enforcement dispatchers regarding this access. Also in Milwaukee, student labor has been applied successfully to updating operations and system documentation (FHWA 1999).

3.6.3. Using a TMC Operations Manual to Support System Maintenance Procedures

During the review of TMCs, only the TMC operations manual developed by the Tennessee Department of Transportation was found to contain information related to system maintenance procedures. Following ITE's recommended content for a TMC operations manual (2001), Tennessee's TMC operations manual describes

- maintenance, startup/shutdown and failure recovery (automated and manual) procedures for daily operation
- maintenance procedures including routine, preventative, emergency (non-routine) and contract maintenance and the location of spare/backup equipment
- system operations logs including maintenance logs and system reports
- control center /system field device descriptions including location, access/security, layout, fire suppression, power source/location, HV/AC and data, voice and network communications
- system documentation including vendor maintenance documentation.

A number of other TMCs cited challenges related specifically to configuration management and preventive maintenance:

Atlanta's TMC recently staffed two full-time positions for configuration management and has a 100 percent configuration review of its software underway (FHWA 1999).

In an innovative way to address the challenge of its changing configurations, Phoenix's TMC recently renewed the multiyear purchase agreement with its preferred variable message signs vendor, providing ADOT total control over the proliferation of brands and models of variable message signs installed in its system (FHWA 1999).

Phoenix has also developed special repair techniques to economically manage ongoing maintenance problems such as damage from gun shot. ADOT performed a logistics analysis to determine appropriate spares levels and how spares should be divided between piece parts and complete units. ADOT also recently completed a study of the 15-year expected cost of maintenance, providing a basis for planning, budgeting, and staffing (FHWA 1999).

To avoid problems with repairing their legacy equipment, TMC personnel in both Toronto and Milwaukee implemented planned system upgrades; Michigan and Long Island TMC personnel were examining methods to continue support for their legacy equipment (FHWA 1999).

3.6.4. Using a TMC Operations Manual to Support Data Collection, Analysis and Warehousing Procedures

Limited evidence of TMC operations manual use to support data collection, analysis and warehousing was uncovered. There was however, a consensus among TMCs that planning, operations and maintenance were all more effective when backed by ongoing performance analysis and process improvement. TMC personnel in both Toronto and Atlanta have performed benefits analysis studies for their respective TMCs. In addition, Atlanta's TMC has a vigorous program of monitoring and evaluating responsiveness to traveler calls. Several TMCs reported evaluating their performance after large or unusual incidents, seeking ways to improve. Most of the newer systems provide fully automated logging of data, status, and actions, making such analysis possible. ADOT has staffed a main shift traffic analyst to perform ongoing analysis of advanced traffic management system collected data, examine operations performance, and identify areas for improving the region's overall traffic conditions for the Phoenix TMC (FHWA 1999). Formal guidance for these types of performance monitoring activities (i.e., performance measures, data to be collected, frequency of analysis, etc.) is lacking in most existing TMC operations manuals.

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4. GETTING STARTED

4.1. Introduction

4.1.1. Chapter Purpose and Key Issues

This chapter describes the roles and relationships of a TMC with various management structures. It also outlines at a high level some of the basic preparatory steps that will be further detailed in subsequent sections.

4.1.2. Relationship to Handbook Document

The first part of this Handbook (Part I) documented the need for and benefits of a TMC Operations Manual. This section provides a transition from Part I with its focus on goals and benefits to subsequent sections that describe the details of developing an Operations Manual.

4.2. Operations Manual Implementation under Various Management Structures

4.2.1. Business Model Perspective Introduction

Traffic management systems and their associated traffic management centers (TMCs) are deployed in many different configurations. The TMC Pooled Fund Study sponsored a *TMC Business Planning and Plans Handbook* activity that characterized TMCs into various management and functional categories as follows. (1)

- Geographic area covered
  - Single jurisdiction TMC
  - Multiple jurisdictions TMC
  - Regional or district TMC
  - Statewide TMC
- Number and types of agencies involved
  - Single agency TMC
  - Multiple transportation agencies
  - Multiple agencies and disciplines
- Operating mechanism
  - Public agency staffed and operated TMC
  - Private sector staffed and operated TMC

The following tables identify some of the characteristics for each business model and describe the potential impacts of this style of management and business enterprise on the development and use of a TMC Operations Manual. The reader should note that these impacts are only advisory and may not substantially affect a specific TMC Operations Manual. They may be very useful in identifying organizations from which to solicit and

review TMC Operations Manuals and historical development activities that can serve as examples for current initiatives.

<Additional details for these tables will be developed for each business model in Draft 2 if the TMC Pooled Fund Project Team approves this approach>

4.2.2. Geographic Area Covered

Geographic definition is probably the most basic decision to be made in developing a Traffic Management System (TMS). Although other categorizations (e.g. multiple agencies, disciplines, operating mechanism) may influence the design and mission of the TMS, geographic definition is basic to any structure.

4.2.2.1. Single Jurisdiction Management

The most common model is the single jurisdiction model. It is probably the easiest structure to operate because decisions and supervision are vested in one entity. In an urban area where there may be multiple other autonomous

Agencies, there may be a measure of cooperation and coordination without a unified management structure or data communication system. Table 1 summarizes characteristics of the Single Jurisdiction Management Structure and the potential impacts on a TMC Manual.

Table 1 --Single Jurisdiction Management Structure

Characteristic	**Potential Impacts on a TMC Operations Manual**
Limited number of stakeholders.	Development of a TMC Operations Manual will involve fewer stakeholders than with other management structures. Therefore, the manual development team and advisory group could be smaller and perhaps reach consensus more quickly.

Table 1 --Single Jurisdiction Management Structure

Characteristic	Potential Impacts on a TMC Operations Manual
Limited number of inter-agency agreements.	Fewer interagency agreements will be required to staff the TMC than with other management structures. However, more interagency agreements could be required to coordinate operations with others in a large multiple jurisdictional region. The inventory and description of interagency agreements could be reduced. Impacts include Section XX of Chapter 5.
Could be located within an existing agency's office facility.	Established policies and procedures for an existing office facility may be applicable Given the influence of transportation operations in some agencies,
With a single jurisdiction it is easier to inventory and track field equipment than with a multiple jurisdiction TMC.	Section XX of Chapter 5.
Agency operations could be more focused on local solutions than the regional mission in a large multiple jurisdictional region.	It may be necessary to carefully examine the text included concerning regional coordination (Section XX of Chapter 5for example) and the material concerning agency responsibilities (Section XX for example).
Coordination with adjoining agencies in a large multiple jurisdictional region could be challenging.	Section XX of Chapter 5.
Resources for operations are typically provided by the operating agency.	To be completed in Draft 2.

4.2.2.2. Multiple Jurisdictions Management Structure

The Multiple Jurisdictions Management Model has application in larger metropolitan areas where multiple jurisdictional boundaries may abut. In a large urban area, a driver can travel on a major thoroughfare and pass through several cities each with its own computer based signal system. While, drivers are not necessarily aware when they cross a jurisdictional boundary, they may be aware if the signal systems are not compatible. Table 2 summarizes characteristics of the Multiple Jurisdiction Management Structure and the potential impacts on a TMC Manual.

Table 2 – Multiple Jurisdictions Management Structure

Characteristic	**Potential Impacts on a TMC Operations Manual**
Efficiency and cost savings. Eliminate duplication and overlap in procurement, installation, and integration of technical systems.	Agreements on maintenance should be developed among the agencies. These agreements should be referenced and summarized in Section XX of Chapter 5. Maintenance procedures described in Section XX of Chapter 5 should reflect the agreements for agency supplied maintenance, contract maintenance and procurement of associated equipment.
Resource utilization and availability. Multi-jurisdictional TMCs are in a position to share and draw upon the technical expertise, strengths and resources of partner agencies. Pooled resources can extend hours and services.	The concept of shared resources should be included in the concept of operation defined in Section XX of Chapter 5. Hours of operations, call in procedures and other staffing considerations described in Section XX of Chapter 5 may need to be tailored to accommodate the policies of each agency if a single policy can not be applied to all agencies. Each agency's operational experiences may have led them to unique logging procedures as a means of risk management. Section XX of Chapter 5 may need to be tailored to accommodate the policies of each agency.

Table 2 – Multiple Jurisdictions Management Structure

Characteristic	Potential Impacts on a TMC Operations Manual
Improved Working Relationships. Collocation of staff from multiple jurisdictions into a common facility facilitates information exchange and elevates trust and understanding.	Collocation and improved working relationships could lead agencies to relax computer system access and administrative polices. The operator interfaces described in Section XX of Chapter 5 should be rigorous enough to allow each agency to control access and use of their equipment and to provide a clear audit path for operator actions.
Systems Coordination. Collocation of staff from multiple jurisdictions into a common facility encourages coordinated traffic management across jurisdictional boundaries	The control system operational procedures identified in Section XX of Chapter 5 should be rigorous enough to allow each agency to control access and use of their equipment.
Could be centrally located for convenient physical access;	To be completed in Draft 2.
Physical location is not critical with adequate communications network providing a "virtual TMC". Lessens the opportunity for trust and understanding among staff.	To be completed in Draft 2.

4.2.2.3. Regional or District Management Structure

The regional or district model is a further iteration of the multiple jurisdictional model. While the multi-jurisdictional model will likely involve jurisdictions in which boundaries abut or a cluster of jurisdictions, a regional or district model will involve such clusters that may be more distantly located. Rural areas may also be incorporated. Table 3 summarizes charac-

teristics of the Regional or District Management Structure and the potential impacts on a TMC Manual.

Table 3 – Regional or District Management Structure

Characteristic	**Potential Impacts on a TMC Operations Manual**
Regional traffic management can occur more easily. May include rural areas as well as urban.	Agreements on maintenance should be developed among the agencies. These agreements should be referenced and summarized in Section XX of Chapter 5. Maintenance procedures described in Section XX of Chapter 5 should reflect the agreements for agency supplied maintenance, contract maintenance and procurement of associated equipment.
Integrated control of multiple ITS systems more easily achieved when one TMC is operation.	The concept of shared resources should be included in the concept of operation defined in Section XX of Chapter 5.
Regional or District TMC may utilize staff from different jurisdictions Collocation of staff from multiple jurisdictions into a common facility facilitates information exchange and elevates trust and understanding.	Collocation and improved working relationships could lead agencies to relax computer system access and administrative polices. The operator interfaces described in Section XX of Chapter 5 should be rigorous enough to allow each agency to control access and use of their equipment and to provide a clear audit path for operator actions.

Table 3 – Regional or District Management Structure

Characteristic	Potential Impacts on a TMC Operations Manual
Regional or District TMC well-suited to serve as a central repository, synthesizer, and clearing house for work zone, maintenance, and construction information for dissemination to traveler information systems.	To be completed in Draft 2.
Arrangement requires intergovernmental agreements, memorandum of understanding, or a concept of operations, be worked out ahead of time	To be completed in Draft 2.
Projects supported by a Regional or District TMC, and inherently by multiple jurisdictions throughout the region e more likely to receive federal approval and funding	To be completed in Draft 2.

4.2.2.4. Statewide Traffic Management Structure

A statewide management structure will be influenced by the geographical size of the state as well as the number of major metropolitan areas contained therein. Although usually the initiator is the state transportation department, other related agencies, such as state highway patrols, may be co-located. Table 4 summarizes characteristics of the Statewide Traffic Management Structure and the potential impacts on a TMC Manual.

Table 4 – Statewide Traffic Management Structure

Characteristic	Potential Impacts on a TMC Operations Manual
Cost efficiencies, particularly in terms of staffing and central system software	To be completed in Draft 2.
Coordination along major corridors that pass through different regions more easily obtained.	To be completed in Draft 2.
TMC serving an entire state requires extensive, costly communications network	To be completed in Draft 2.
May be operated by single state agency or with shared operation of other state agencies (DOT, highway patrol)	To be completed in Draft 2.

4.2.3. Number and Type of Agencies Involved

Previously described models have centered on geographic and jurisdictional considerations; the agency focus expands the jurisdictional aspects to related agencies. Geographical considerations may still influence some of the agency models.

4.2.3.1. Single Agency Management Structure

This structure, with a single agency (e.g. traffic department) within a jurisdiction has many of the same characteristics of the single jurisdictional structure. Table 5 summarizes characteristics of the Single Agency Management Structure and the potential impacts on a TMC Manual.

Table 5 – Single Agency Management Structure

Characteristic	**Potential Impacts on a TMC Operations Manual**
All of the control resides within one organization; decisions made without consulting other agencies	To be completed in Draft 2.
May have a limited view of the regional approach to traffic management	To be completed in Draft 2.
Many of the same characteristics as single jurisdiction model, e.g. inter-agency agreements may not be required.	To be completed in Draft 2.
Economic, human resource, technical expertise limitations of single-agency TMCs may limit the breadth and scope of activities	To be completed in Draft 2.
Implementation costs are typically higher when each agency develops their own TMC, versus having one TMC facility that is shared among multiple agencies	To be completed in Draft 2.

4.2.3.2. Multiple Transportation Agency Management Structure

This structure would be characterized by the alliance of several transportation agencies, e.g. transportation departments of two or more cities combine forces to operate the traffic signal systems of the two agencies as a single system.

The definition of this structure would not include related agencies such as enforcement. Table 6 summarizes characteristics of the Multiple Transportation Agency Management Structure and the potential impacts on a TMC Manual.

Table 6 – Multiple Transportation Agency Management Structure

Characteristic	**Potential Impacts on a TMC Operations Manual**
Traffic management can be handled across jurisdictional boundaries more effectively.	To be completed in Draft 2.
Would not include public safety elements in center; communications may suffer	To be completed in Draft 2.
Intergovernmental agreements must be executed and operational procedures documented; this is advantageous as that it requires cooperation among the staff of the different transportation agencies.	To be completed in Draft 2.
Any given agency may have to comprise on how they operate their.	To be completed in Draft 2.

4.2.3.3. Multiple Agency and Disciplines Structure

Because of the complex nature of Multiple Agency and Disciplines Structure, it will the most difficult to implement. Numerous interagency agreements and agreed upon operating policies and procedures will need to negotiated. However, the cost efficiencies and the benefits of coordinated management will usually outweigh these complexities. Table 7 summarizes characteristics of the Multiple Agency and Disciplines Structure and the potential impacts on a TMC Manual.

Table 7 – Multiple Agency and Disciplines Structure

Characteristic	Potential Impacts on a TMC Operations Manual
Efficiency and Cost Savings – Multi-agency TMCs eliminate duplication and overlap in construction and maintenance of facilities; compatible and integrated systems (e.g. Integrated CAD) allow agencies to share costs for new purchases and upgrades.	To be completed in Draft 2.
May be from same jurisdiction or municipality, typically transportation and public safety.	To be completed in Draft 2.
More difficult to implement but has many of same advantages of multi-jurisdictional model	To be completed in Draft 2.
Improved Communications and Working Relationships – Collocation of staff of multiple facilitates information exchange, elevates trust and understanding. Agencies see the impact of their activities on the missions of other agencies.	To be completed in Draft 2.

4.2.4. Operating Mechanism

Either of the two operating mechanisms described below may apply to the previously described management structures. Table 8 summarizes charac-

teristics of the Public Agency Staffed and Operated Management Structure and the potential impacts on a TMC Manual.

4.2.4.1. Public Agency Staffed and Operated Management Structure

This is perhaps the preferred model for most agencies since they will have direct control and management of their system. This assumes that adequate funding is available for both operational activities and personnel. Table 8 summarizes characteristics of the Public Agency Staffed and Operated Management Structure and the potential impacts on a TMC Manual.

Table 8 – Public Agency Staffed and Operated Management Structure

Characteristic	**Potential Impacts on a TMC Operations Manual**
Staff and operate the TMC with personnel from the jurisdiction and agency that owns the TMC. Requires hiring personnel that have the skills or interest in the "operation" of a traffic management center.	To be completed in Draft 2.
Staff comprised entirely of public-agency employees is ideal. Unified personnel management system facilitates team cohesiveness. Greater sense of ownership of day-to-day as well as emergency operations.	To be completed in Draft 2.
Funding and staffing restrictions have been a continual problem for many agencies.	To be completed in Draft 2.

4.2.4.2. Contract Operation Management Structure

Depending on available funding, all or a part of the operational responsibilities may be contracted to a private organization or even another agency. Table 9 summarizes characteristics of the Contract Operation Management Structure and the potential impacts on a TMC Manual.

Table 9 – Contract Operation Management Structure

Characteristic	Potential Impacts on a TMC Operations Manual
Outsourcing allows agencies to specify qualifications of staff needed and to place the responsibility for hiring and training staff on a private company.	To be completed in Draft 2.
May be easier for public agency to find funds for contracted operations staff rather than approval and budget to hire their own staff.	To be completed in Draft 2.
Introduces contractual issues, and the required administration, oversight, and performance measurement of the contractor	To be completed in Draft 2.

4.2.5. System Maturity Perspective

In the case of a new system or a major upgrade to existing facilities and infrastructure, there is an opportunity to develop a TMC Operations Manual over the life of a project. For example work in identifying a regional and system concept of operations could provide information for sections such as the following.

- Interagency and inter-jurisdictional coordination (Section XX of Chapter 5)
- Definition of the control area (Section XX of Chapter 5)

- Agency responsibilities in developing traffic signal timing plans (Section XX of Chapter 5)

More detailed procedures for equipment operation would be developed at subsequent phases of the systems engineering life cycle.

In a "mature" system where no new system upgrade is eminent, the TMC is likely in the operations and maintenance phase of the life cycle for the foreseeable future. Therefore, there is not the built-in motivator of "new construction" with its associated funding stream to encourage broad participation throughout an organization.

<Additional text will be provided in Draft 2>

4.3. Getting Ready

With more effective operations there is more effective system performance.

Operations affect outcomes. With more effective operations there is more effective system performance. And with a strategy to formulate a TMC Operations Manual that mirrors and guides effective operations (as measured through accepted, responsive and appropriate performance measures) there is a need to build consensus.

The steps required to develop and implement a TMC Operations Manual are as follows.

- Identification of a champion
- Establishing a manual development team
- Identifying appropriate stakeholders
- Designating an advisory group
- Collection and assembly of relevant system documents
- Collection and assembly of regional agreements and ITS Plans
- Establishing a schedule and assigning responsibilities

After the development of the TMC Operations Manual, it must be used and managed

- Implementing the TMC Operations Manual
- Providing training on the use of the TMC Operations Manual
- Updating the TMC Operations Manual

<Additional text will be provided in Draft 2>

4.4. Notes and References

1 The TMC Pooled Fund Study sponsored a project to develop a *TMC Business Planning and Plans Handbook* during the 2004 – 2005 time period. The Pooled Fund web site is located at http://tmcpfs.ops.fhwa.dot.gov. At the time the Operations Handbook was completed the drafts of the Handbook could be found at http://tmcpfs.ops.fhwa.dot.gov/cfprojects/new_detail.cfm?id=54&new=0.

5. TMC OPERATIONS MANUAL COMPONENTS

5.1. Introduction

<A few of these sections in Chapter 5 Draft 1 contain recommendations about who may be able to provide the information for each topic and when in the systems engineering process this information could be gathered. See Sections 5.2.3, 5.3.3.11 and 5.3.3.12 for examples. The plan for Draft 2 is to include this information for each topic. It will also include additional text for many of the topics that are carried forward into Draft 2.>

5.1.1. Chapter Purpose and Key Issues

This chapter describes the components that could be included in a TMC Operations Manual. It is important to note that not all items listed in this chapter are meant to be included in every TMC operations manual. Selection of specific components will be dependent on the management structure of the TMC, services offered by the TMC, the availability of supplemental manuals and procedures, and the size and complexity of the center.

5.1.2. Relationship to Handbook Document

Earlier chapters have identified the context and benefits of a TMC Manual. Subsequent chapters deal with procedures for developing a manual and case studies of successful practice. By providing a description of suggested content this chapter allows an agency to review their organizational structure and setting in order to develop a tailored outline applicable for their conditions. Using this customized outline as a set of requirements for their TMC Operations manual, the organization can subsequently develop the activities and resources required to produce the document, to train operational staff on the use of the manual and to provide ongoing updates in response to changing circumstances. An implementation path can then be pursued to successfully implement the TMC Operations Manual.

5.2. Inventory

A comprehensive inventory of documentation for existing and planned TMC related-items must be assembled to aid in the development of the handbook. This will include any existing procedures as well as an inventory of existing field equipment and communications hardware and media central management components. Information sources will include existing agency files and records, but in some cases may require a physical inventory.

5.2.1. Area of coverage

Geographical areas for which the TMC will perform services must be defined as well as sub areas and sub facilities. Text descriptions as well as hard copy maps should be developed. Municipal boundaries, transit service areas, and other geographic boundaries should be included.

5.2.2. Functions

If you don't know where you are going, you will probably wind up somewhere else.

Functions which the existing TMC currently performs, or which an upgraded or new TMC will perform, should be documented. Sources for this information will include existing operations manuals as well as planning documents such as an operational concept document (OCD) that has been reviewed and approved in concept by all entities that will be housed in or will interface with the TMC. It is imperative that an OCD or similar document be in hand before the TMC Operations Handbook development begins.

5.2.3. Services Provided

Functions describe what the system is designed to do. Services describe what those functions will do and for whom. A comprehensive list of the services the system will provide and who (public and private agencies, drivers) will receive these services should be developed for use in developing the Manual.

The information for these "services" could be contributed by the Planners and FHWA Field Staff who played a role in the development of the Regional ITS Concept of Operations and in planning for ITS. The information could be provided during the early phases of the systems engineering process for a project, including the development of a concept of operations.

5.2.4. Field Devices

An inventory of existing field control, information, and communications equipment that will be utilized in the traffic management system must be assembled. A similar inventory of planned field equipment to be installed in a new or upgraded system must also be assembled.

5.2.5. TMC Components

An inventory of existing control and system management equipment that will be utilized in the traffic management system must be assembled. A similar inventory of existing control and system management equipment to be installed in a new or upgraded system must also be assembled.

5.2.6. Stakeholders

Most transportation management systems (TMS), particularly in larger urban areas, have a relationship to other TMS in the area. There may be data and information exchange and coordination of management tasks. At the very least there will be informal communication among agencies. An inventory of stakeholders should be undertaken. Stakeholders in surface transportation management may include:

- State transportation agencies
- Local municipalities
- Area transit agencies
- Toll authorities
- Private information service providers
- Regional mobility agencies
- Metropolitan planning offices

5.3. Daily Operations

Components of an operations manual to support daily operations of a TMC must be identified. The components include but are not limited to: personnel and organizational structure, hours of operation, staffing requirements, operations concept, policies and procedures, control plans, remote operation, security procedures, startup and shut down procedures, failure recovery, command structure, emergency contact numbers, notification procedures, operational logs, maintenance policies, procedures, and plans, data archiving and warehousing, emergency procedures, and inter-agency coordination.

5.3.1. Emergency and Other Contact Numbers

This a quick reference for emergency situations. Depending on agency (Municipal, State Highway, Tollway, Transit, etc), contacts will be subdivided into: inter-agency; intra-agency; and private entities. Typical contacts include the following.

- TMS Operations, maintenance and supervisory personnel contacts (home phone number, pager, cell hone number, portable communications device email address, instant messenger ID)
- Police, fire, EMS, motorist assistance patrols, PSAP
- Street maintenance, freeway maintenance
- Private information providers, media
- Other

In regions characterized by a large number of jurisdictions, supplemental maps illustrating the physical boundaries for agency responsibilities should be included.

5.3.2. TMC Emergency Plan

These procedures will serve as a quick reference for emergency action in the control room (not traffic management or homeland security issues).

Specify operator action in the case of occurrences such as those shown below. Some actions will be standard operating policies of the agency and may be included by reference although it is more expeditious to have those procedures in the most accessible console document, which in most cases will be the Manual.

5.3.2.1. Fire

Specify actions to be taken in the event of building fire or equipment fire. Notification of proper authority as well as equipment safeguarding and personnel safety should be specified.

5.3.2.2. Smoke

Specify actions to be taken in the event of building smoke or equipment smoke. Notification of proper authority as well as equipment safeguarding and personnel safety should be specified.

5.3.2.3. Flood

Specify actions to be taken in the event of flooding due to either external conditions or building plumbing. Notification of proper authority as well as equipment safeguarding and personnel safety should be specified.

5.3.2.4. Earthquake

Specify actions to be taken in the event of earthquake. Notification of proper authority as well as equipment safeguarding and personnel safety should be specified.

5.3.2.5. Security

Describe security for building/control room entry and exit in an emergency.

5.3.2.6. Power Loss

Specify actions to be taken in the event of power loss either to equipment or to the facility. Notification of proper authority as well as equipment safeguarding should be specified as well as steps to be taken to activate back-up power if it is not automatically implemented.

5.3.2.7. Communications Loss

Specify actions to be taken in the event of communications loss either to equipment or to the facility. Notification of proper authority as well as equipment safeguarding should be specified.

5.3.2.8. Evacuation

Describe under what conditions and what actions should be taken in the event building evacuation is necessary.

5.3.2.9. System Shutdown

List the basic steps to shutdown system in a manner to minimize corruption of hardware and software.

5.3.2.10. System Startup

List the basic steps to startup the system after a manual shutdown.

5.3.2.11. System Failure Recovery

Steps for system recovery from and unexpected shutdown should be specified if they are different from the startup procedures.

5.3.3. General Policies

The handbook should include a statement of general policies related to daily operation, security, administrative procedures, etc. Many of these policies may be stated in an overall agency Human Resources or other policy. However, those policies that may be especially important to system operation may bear repeating.

5.3.3.1. Documentation of Manual Updates

- *Version and date of current manual* On the title page of the handbook, the version number and date of the overall document should be indicated.
- *Change Policy* A policy and/or procedure should be developed which documents steps to be taken for changes to the handbook. The policy should detail to whom the request for changes is made and the approval authority for such changes.
- *Update Status and Record* A method for maintaining a record of changes and updates to this handbook should be developed. A tabular record that documents changes by date, page and section number should be a part of the handbook.

5.3.3.2. Procedure and authorization to change/suspend policy

There may be occasions and circumstances where it may be necessary to change or suspend a policy or procedure. The procedure for submitting a request and who is authorized to approve such a request should be documented in the handbook.

5.3.3.3. Outside agency authority

There may be situations when system operators are directed by an outside agency to take action (e.g. FBI directs operator to display message on DMS as happened in one center on 9/11). A clear statement of procedures for approval of outside authorities or agencies to direct use of the system must be included in the handbook.

5.3.3.4. Severe weather conditions

A statement of actions for personnel in severe weather (do they come in to work, can they leave work, who authorizes) should be included in the handbook.

5.3.3.5. Authorization, scheduling, and handling of visitors

A TMC has numerous visitors ranging from local interest groups to other related operations agencies to representatives from other states seeking information on state of the practice in freeway management. Procedures for requesting such visits and tours should be specified to include the person or person to whom the request should be directed. The policy should outline the responsibilities of the TMC staff on such occasions.

5.3.3.6. Citizen inquiry and service requests

There will be occasions where TMC personnel will be directly in communication with citizens by telephone or other electronic means. Procedures for responding to citizens, logging requirements, referral, response requirements, follow-up, and other actions should be documented. Describe typical telephone etiquette, answering greeting, circumstances for referral to other parties, and other agency telephone policies.

5.3.3.7. Contact with Media and the Public

A typical TMC may receive numerous requests for information from media sources. The handbook must specify who can talk to media, what information may be given, and to whom media inquirers should be referred for further information.

5.3.3.8. System and Non-System Equipment

In addition to typical office equipment, there will other advanced technological equipment related the transportation management tasks. Specific policy on use of such equipment should be included in the TMC Handbook including:

- General Office Equipment
- Operator Specific Equipment
- General Agency Property
- Telephone and Fax Usage

5.3.3.9. TMC Building Cleaning and Maintenance

Because of security and the types of high tech and costly equipment housed in the TMC, it may be necessary to schedule building cleaning and maintenance activities when the TMC is staffed. Specific schedules and procedures should be detailed in the handbook.

5.3.3.10. Building Security

Building security is an important consideration for a TMC because of the sensitive nature of the mission and the types of high tech and costly equipment housed there. Considerations include:

- Allowable access to the building
- Pass keys/keypads and controlled access
- Allowable access to control, communication, and equipment rooms

5.3.3.11. Organization Chart and Work Shifts

In order to clarify the operational chain of command the TMC manual should include an applicable organization chart relevant to TMC staff. This is especially useful during an incident or disaster where interactions within the center and to external emergency operations personnel are critical. When a center has co-located functions (like transit or 9-1-1) the chain of command information for each agency should be included.

It is also useful to have a clearly defined callout policy and procedure that can be used to bring supplemental staff to the TMC in times of emergency. Together with a clear set of work shift guidelines these staffing resources form a base for ensuring that adequate personnel are available to meet the services promised in the concept of operations.

If not included in the Manual the location of relevant organization charts and work shift guidelines should be specified.

When contract TMC staff is involved in operations the information may need to be partitioned for each organization.

The information for these "organization chart and work shift" topics could be contributed by the Operations Managers/Supervisors, Systems Administrators and Human Resources Staff. The information could be provided during the early phases of the systems engineering process for a project, including the development of a concept of operations.

5.3.3.12. Other Workplace Policies

Miscellaneous policies such as those mentioned below are typically covered by existing agency policies. And it is not unusual for new employee orientation and recurrent training to include information on them. It is still prudent to include a brief paragraph or two in the TMC Operations Manual indicating that these policies exist and referencing where additional information on the specifics of these policies can be found.

The use of contract TMC staff, part-time personnel and student labor can sometimes change the scope and applicability of these policies. It may be necessary to partition the description of these workplace policies into appropriate job classifications and employment arrangements so that it is clear to whom they apply.

- Breaks
- Drug-free workplace policy
- Meals
- Nondiscrimination
- Overtime
- Smoking policy
- Uniform and dress code

The information for these "other workplace policies" could be contributed by the Human Resources Staff and Legal Staff / Contract Specialists. The information could be provided during the early phases of the systems engineering process for a project, including the development of a concept of operations.

5.3.4. General System Operation

5.3.4.1. Management Center Functions

Describe general TMC functions. Refer to more detailed operations and functions in subsequent sections.

5.3.4.2. Control Center Description

- Location
  Detail street and mailing address, location within agency grounds, and latitude/longitude. Provide map of general area showing TMC location.

- Layout
  Provide general plan view layout of TMC building and detailed plan view of the control room to include the following.
  - Consoles
  - Displays
  - Voice communication devices
  - Fire suppression
  - Power source location
  - HV/AC
  - Data communications
  - Network communications

- Personnel
  Describe typical staffing including job titles and brief duties, and designated supervisor for shifts. Provide operations, maintenance and supervisory personnel contacts (home, pager, cell)

- Hours Of Operation
  Specify hours of operation for workdays, holidays, weekends, nights, special events, and emergencies. Note procedures for authorizing non-weekday operations.

- After Hours On-Call Roster
  Provide a list of contact numbers (home, pager, cell) for operations, maintenance and supervisory personnel contacts

5.3.4.3. Remote Operation

Describe circumstances for remote operation, authorization, and designated personnel.

5.3.4.4. Security Procedures

This section should describe security procedures for the control system to include control of access to system interfaces and various levels of access to specific functions of the system.

5.3.4.5. Maintenance Checklist

Typically the system operator will form only routine maintenance on the system. However, there will be certain routine maintenance checks and minor repairs that may be performed. The maintenance checks and responses should be described as well as what actions to take for failures beyond that list (contact numbers for technician or service contractor).

5.3.4.6. Coordination and Dispatch of Motorist Assistance Patrols (Freeway)

Many freeway management systems involve operation or coordination with a motor assistance patrol.

5.4. Operational Concepts – Freeway Management Systems

Describe the overall system operation concept enabling user to visualize goals, objectives, and how the discreet parts fit together to accomplish those objectives

5.4.1. Goals of the Traffic Management System

Provide a concise statement of goals and objectives of the TMC and how general components work together (Detection, response, data collection and storage)

5.4.2. Interagency and Inter- Jurisdictional Coordination

Describe the need for interagency and inter-jurisdictional cooperation and coordination with other stakeholders. Describe other systems and briefly what types of data and information will be exchanged and how coordination of operation can be accomplished.

5.4.3. Malfunction Response

Delineate response to system hardware and software malfunctions in the control center and hardware malfunctions for field equipment. Describe notification and dispatch of maintenance personnel and logging of malfunction and resolution of problem.

5.4.4. Traffic Monitoring

Describe traffic monitoring devices such as:

- Speed Detector Monitoring and Response
- Closed Circuit Television (CCTV)
- Recording Video Images
- Road Construction Monitoring

- Highway Maintenance Activity

5.4.5. Traffic Response

Describe response to planned or unplanned events.

5.4.5.1. Dynamic Message Signs (DMS)

Provide overview of the uses of DMS
- DMS Message Priority
- Display of Travel Times
- Blank Signs
- Operation of DMS by Law Enforcement Personnel

5.4.5.2. Traffic Diversion

Provide a general description of when diversion is warranted and policy on diverting to specific roadways
- Full Freeway Closure
- Partial Freeway Closure
- Diversion to Roadways Not Under the Jurisdiction of Agency

5.4.5.3. Highway Advisory Radio (HAR)

5.4.5.4. Lane Control Signals (LCS)

5.4.5.5. Ramp Metering

5.4.6. Field Devices – Freeway Systems

This topic should contain a functional description of freeway field device capability and specify the locations of field devices being controlled or monitored by the traffic management system. Typical field devices could include the following.
- Closed Circuit TV (CCTV)
- Communication Media
- Detectors
- Dynamic Message Signs (DMS)
- Highway Advisory Radio (HAR)
- Lane Control Signals (LCS)
- Ramp Meters
- Other

5.5. Control System Operation Procedures-Freeway Management Systems

This section will depend to a great extent on the individual system but typical functions can be modified or deleted if not applicable. Most of the required information will be found in the documentation provided by the system installation contractor/integrator

5.5.1. System Start-Up Procedures

5.5.2. System Shut Down Procedures

5.5.3. Operator Interface

In addition to operation procedures, typical pictures of interfaces where applicable may be provided. Operator interfaces will include:

- Operator Console
- Field Communication
- Closed Circuit TV (CCTV)
- Dynamic Message Signs (DMS)
- LCS
- HAR
- Police Communication

5.5.4. Incident Management Procedures

<Procedures will vary widely among agencies but an example will be provided in the next version of the handbook.>

Response will include both actions to be taken to respond as well as notification of other agencies.

5.5.4.1. Reported Incidents

5.5.4.2. Detected Incidents

5.6. Operational Concepts – Traffic Signal Management Systems

Describe the overall system operation concept enabling user to visualize goals, objectives, and how the discreet parts fit together to accomplish those objectives

5.6.1. Goals of the Traffic Signal Management System

Concise statement of goals and objectives of the TMS and how general components work together (Detection, response, data collection and storage)

5.6.2. Interagency and Inter-Jurisdictional Coordination

Describe the need for interagency and inter-jurisdictional cooperation and coordination with other stakeholders. Describe other systems and briefly what types of data and information will be exchanged and how coordination of operation can be accomplished**.**

5.6.3. Control Area

Describe in text, supplemented by a map, the control area, number of signals, map, system boundaries, jurisdictional boundaries, and coordination with other operating agencies.

5.6.4. Traffic Signal Operations

Describe in text, supplemented by a map, region/sector: isolated, pretimed, traffic responsive, system coordination, adaptive operation, etc.

5.6.5. Agency Responsibilities in Developing Signal Timing

Denote who within the agency determines signal timing parameters, schedules, update frequency, and other operations functions.

5.6.6. Field Devices Traffic Signal Systems

Provide functional description and locations of traffic signal field devices:

- Signal Heads
- Controllers
- Detectors
- LCS
- DMS
- CCTV
- Communication Media
- Other

5.7. Control System Operation Procedures-Traffic Signals

This section will depend to a great extent on the individual system but typical functions can be modified or deleted if not applicable. Most of the required information will be found in the documentation provided by the system installation contractor/integrator

5.7.1. System Start-Up Procedures

5.7.2. System Shut Down Procedures

5.7.3. Operator Interface

In addition to operation procedures, typical pictures of interfaces where applicable may be provided. Operator interfaces will include:

- Operator Console
- Signal System Interface
- Field Communication
- Closed Circuit TV (CCTV)
- Dynamic Message Signs (DMS)
- Lane Control Signals (LCS)
- Police Communication

5.7.4. Incident Management Procedures

Response will include both actions to be taken to respond as well as notification of other agencies.

5.7.4.1. Reported Incidents

5.7.4.2. Detected Incidents

5.8. TMC Maintenance Procedures

Routine maintenance to be performed by operators. Anything beyond that would be performed by contract or agency maintenance personnel**.**

5.8.1. Routine Maintenance

Typical daily checks, adjustments, and component exchange

5.8.2. Preventative Maintenance

Denote scheduled maintenance by agency maintenance personnel or contractor

5.8.3. Spare/Backup Equipment

Provide inventory of spare and backup equipment and listing of vendors and suppliers**.**

5.8.4. Emergency

Describe notification procedures for major failures

5.8.5. Agency Maintenance

Provide listing of maintenance to be performed by agency personnel.

5.8.6. Contract Maintenance

Describe criteria for calling in contract maintenance and provide, phone, fax, and pager listings. List agency personnel to authorized call in outside contract or on-call List the agency personnel to authorized call in outside contract or on-call the maintenance provider**.**

5.9. System Operations Logs

Provide historical logging procedures (manual and automated) as determined by management within capability of specific system.

5.9.1. Incidents and Events

Planned and unplanned events, road closures, incidents, etc

5.9.2. Operations

Operations periods, on-line/offline times, manual intervention, etc

5.9.3. Maintenance

Malfunctions, outages, resolution of problem, etc

5.9.4. Citizen Requests

Requests for service, complaints, compliments, reports of field outages, etc.

5.10. System Reports

Describe system reports that may be generated automatically or require manual intervention. These may include system evaluation parameters, maintenance, or other information of interest.

5.11. Traffic Data Collection and Storage

Describe what types of historical data, analyses, and other types of traffic data may be collected and stored and what storage medium will be used.

5.12. Risk Management

Provide guidance of what types of data to store and for how long in response to agency risk management policies.

5.13. System Documentation

Provide a list of system documentation and where it is stored.

5.14. The Organizational Setting

Few Transportation Management Centers (TMCs) operate in isolation from other agencies and jurisdictions. The handbook should reflect those other organizations as they relate to the mission and goals of this particular agency and what mutual agreements, formal and informal, exist. Transportation and traffic system operators and providers and other stakeholders should be identified along with the services they provide and how those services relate to this agency. These related agencies may have been identified or participated in the development of the Operational Concept Document or other planning activities.

5.14.1. Service Providers and Stakeholders

Communication with other organizations with an interest and stake in traffic and transportation system operation should be initiated. Where possible, missions, goals, functions and services provided and supported, roles and responsibilities of these organizations should be assembled and reviewed. Potential organizations include:

- State agencies
  - Freeway operations
  - Enforcement
- Local municipalities (cities and counties)
  - Traffic operations
  - Enforcement
  - EMS
- Area transit agencies
  - Traffic operations
  - Enforcement
- Toll authorities
  - Traffic operations
  - Enforcement
- Private information service providers
  - Media
  - Traffic patrols
- Regional mobility agencies
- Metropolitan planning offices

5.14.2. Agreements, Contracts, and Memoranda of Understanding

Existing contracts, agreements, and memoranda of understanding should be assembled and reviewed to determine what existing relationships are in effect. This activity may reveal the need for additional agreements.

5.14.3. Advisory Functions of Other Related Organizations

Other related organizations may have been involved and had input during the concept phase and preliminary design of a transportation management system. It may be of benefit to involve them at certain points during development of the handbook. This is essential if the agency will coordinate operations or otherwise communicate with the agency developing the handbook.

5.15. Organizational Representation within the TMC

Organizational representation within the TMC is closely related to the organizational setting described above. There may be multiple subunits within an agency such as a city traffic department, city police department, and city EMS in addition to entities external to the city. The handbook must account for the physical presence as well as the level of operational functions which may be performed or the data and information which may be accessed..

5.15.1. Potential Agencies in TMC

One or more of the stake holders and agencies identified above may be co-located in the TMC. These may include:

- State agencies
  - Freeway operations
  - Enforcement
- Local municipalities (cities and counties)
  - Traffic operations
  - Enforcement
  - EMS
- Area transit agencies
  - Traffic operations
  - Enforcement
- Toll authorities
  - Traffic operations
  - Enforcement
- Private information service providers
  - Media
  - Traffic patrols

5.15.2. Operating Agreements

Likely, formal agreements will have been executed that detail roles and responsibilities. Review of these agreements and dialogue with the affected agencies will be necessary to development of the handbook: The need for additional agreements may be identified.

5.15.3. Roles and Responsibilities

Based on agreements mutually developed and executed, specific roles and responsibilities should be spelled out. For example, police personnel may be housed in the TMC with access to a console that provides continuous information on operational conditions and incidents. They may have the ability to call up specific screens but may not have the authority to make changes to sign messages. In some TMCs, police authorities may operate DMS during hours when the TMC is not otherwise staffed. Whatever the circumstances, it is essential that the roles and responsibilities be in the handbook and that all parties have access to documentation of those roles and responsibilities.

5.16. Performance Monitoring

In recent years, one of the key concepts implemented by agencies and TMCs to improve transportation systems is performance measurement (also called performance monitoring). Performance measurement is a process which allows an agency to collect and evaluate information for the purpose of assessing progress towards goals and objectives, as well as increasing efficiency and meeting customer expectations. Performance measurement seeks to answers the “big-picture” questions such as:

- How well are we operating our roadways?
- Are we meeting our goals?
- Are our customers satisfied?
- What improvements are necessary?

With origins in the concept of total quality management from the early 1940’s, performance measurement has evolved as a scientific tool utilized by hundreds of industries world-wide. In a nutshell, the process utilizes statistical evidence of current conditions to compare against agency defined targets or benchmarks. These statistics are gathered in support of defined viewpoint rather into the system, also known as performance measures.

The performance measurement process can be implemented in nine steps as outlined below:

1. Identify the critical activity

2. Identify the goals and objectives of the activity
3. Develop a set of candidate performance measures
4. Identify performance targets
5. Identify uses of performance measures and potential audiences
6. Identify data needs and requirements for analytical tools
7. Establish data collection and evaluation procedures
8. Compare actual performance to targeted goals
9. Determine corrective actions or progress needed to achieve goals

The reader should understand that the above process is an iterative evaluation methodology. This dictates an on-going review and refinement procedure. The process will be explored in detail in Chapter 6 of this manual.

5.16.1. Challenges and Benefits

A TMC implementing a performance measurement system will find both challenges to overcome and benefits to reap. A major challenge is the on-going and systematic collection of data required to supply the process. Most TMCs are only just now beginning to collect and store this type of information. While the primary benefit to a TMC is the continual focus on the core mission of meeting customer's needs and expectations, many TMCs have also shown benefits in areas of accountability, efficiency, effectiveness, communications, and planning.

5.16.2. Performance Measures

At the heart of the process are the measures themselves. There are thousands of potential measures that a TMC can use. The key is to choose measures that can measure specific progress towards goals. A good measure has four main traits. It should:

- Measure the right item – Focus on goals and objectives and determining if they are being met. Remember that performance measurement can be used not only for operations, but for other areas as well.
- Be accepted – The measure should be simple, understandable, unambiguous, and meaningful to the customer. Don't be afraid to use different measures for different customers.
- Be responsive – A performance measure that is insensitive to events will not be meaningful because it can not adequately show progress towards goals.
- Be appropriate – Selected measures generally have requirements for both timeframe and geographic location. Understanding these requirements allows for the proper application.

Another aspect to keep in mind is to balance the data collection needs. Measures that require new and expensive data collection efforts are not likely to be successful. This doesn't mean that a TMC shouldn't stretch

beyond current practices. Indeed, many agencies have fallen into the trap of only looking at measures that can be supported by data they already collect. This can hinder effective evaluations and often results in choosing measures that don't support the stated goals.

5.16.3. Keys to a Successful Program

A successful program of performance measurement embraces several key principles. These principles are not rigid parameters, but are meant to provide guidance and common sense advice to organizations.

- Keep the number of measures manageable – Include significant measures but refrain from using measures merely because they are interesting.
- Use a balance of measures – Utilize measures that cover the broad range of responsibilities and tasks performed by the TMC. Remember that some measures are more suited to a particular audience. Ensure that the selection of measures is adequate for each group of stakeholders.
- Be flexible – Don't be afraid to test new measures, to find the right mix.
- Go beyond the basics – While simplicity is attractive don't shy away from the "hard" issues, as this is what pushes a TMC to grow and provide better service to the stakeholders.
- Establish regular reviews – Utilize regular review to keep the process fresh and up-to-date with current operational and stakeholder needs.

5.16.4. Other Aspects of Performance Measurement

This section has provided an overview of establishing a performance measurement process, as well as discussed some of the important aspects of selecting and utilizing measures. There are however, many other important aspects to establishing a performance measurement process. The reader is referred to Chapter 6 for a comprehensive treatment of:

- Data collection needs
- Establishing performance measurement thresholds
- Reporting performance measurement data

In addition, Chapter 6 provides significant detail on the differences in performance measurement between rural and urban TMCs. Urban TMCs are typically established operations while many rural TMCs are just getting started. The overall goals of these systems may be quite different and the performance measurement process should reflect that individuality.

6. DEVELOPING AND UPDATING A TMC OPERATIONS MANUAL

6.1. Introduction

6.1.1. Chapter Purpose and Key Issues

Starting with Chapter 6, this text presents in-depth discussions of some of the critical issues that face TMCs. In particular, this chapter introduces the concepts and components of a systematic performance measurement process to objectively evaluate progress towards stated goals. The chapter also delves into significant detail on individual topics such as the choice of performance measures and the collection of performance data.

The recognition of a performance measurement system (and other aspects, presented in future chapters) as a key component of standard TMC procedures dictates that that operators and other TMC personnel will need to understand and support the systems with a significant level of understanding and expertise.

The key factor for the reader to keep in mind as they explore this chapter is that a TMC operations manual must provide the detailed information necessary to create this understand and expertise.

Not only should an operations manual detail the specific process and steps a TMC will utilize in a performance measurement system, it should list all of the particulars, including what performance measures are to be utilized, what are the performance targets, what are the analysis procedures and where and how should the data be obtained and analyzed. The manual should also identify the recipients or end-users of the performance data, by explicitly relating what are the target groups and how the information should be presented. Along with tabular presentations of the goals, objective, measures and targets, visual examples of performance measurement calculations and presentations should be provided to give guidance to TMC personnel.

Finally, the operations manual should also detail the on-going evaluation process, including comparison timeframes, again, with a visual example of how comparisons should be made and recorded for historical record-keeping.

These topics will be explained in detail throughout the rest of this chapter. Readers should follow the discussions with an overall goal of not only developing their process, but documenting it in explicit detail as the primary reference for TMC personnel.

6.1.2. Relationship to Handbook Document

Previous chapters of this manual have provided a context for understanding the need for a TMC operations manual. In particular, discussions have presented the typical functions of a TMC as well as example management structures, daily operations, and typical staffing.

This chapter continues the development of additional depth by building upon these concepts and presenting a methodology for a systematic and on-going process of evaluation. This evaluation capability is a crucial tool in developing a TMC that is focused on customer goals and a self-sustaining programming of continual monitoring and improvement.

Future chapters of this manual support this process by providing significant levels of detail about specific agency functions, such as traffic monitoring and traffic response. These and other functions are a part of the big picture concept of daily operations. Sufficient detail is presented on these topics, allowing operations personnel to develop significant expertise in each individual function area.

The combination of detail pertaining to each function as well as the solid framework for performance measurement presented in this chapter can be utilized by the reader to develop an on-going evaluation program that utilizes many of these specific functions in support of daily TMC operations.

6.2. Creating a TMC Manual from Scratch

<Section 6.2 to be developed in Draft 2>

This section will discuss issues related to developing a TMC operations manual, as constraints, institutional issues, and other key factors that influence the update or initial development of a TMC Operations Manual. A recommended procedure (general guidelines) for developing a manual will be presented, that includes identifying stakeholders and how to integrate them into the process of developing or updating an operations manual should also be identified.

6.3. Updating an Existing Manual

<Section 6.3 to be developed in Draft 2>

This section will discuss the main differences between developing and updating an Operations Manual for a TMC. Potential topics include data, information sources, analytical tools, and analysis that should be performed in support of identifying recommendations for the TMC.

6.4. Dealing with TMC Complexity and Maturity

<Section 6.4 to be developed in Draft 2>

This section will discuss, in general terms, how the guidance and concepts presented in this chapter may differ for various s types of TMCs (complex, basic, mature, new, etc)

6.5. Dealing with Urban and Rural Characteristics

All TMCs are not created equal. While that's a rather obvious statement, it's critical to understand the underlying point. TMCs across the nation differ in multiple ways, such as:

- Area of coverage
- Hours of operation
- Size
- Physical location
- Physical facilities
- Staffing and resources
- Operating characteristics
- Stakeholders

These differences are not bad or even problematic; they simply exist and must be recognized. The concept that one size fits all, or that one solution is *the* right solution is not valid when discussing TMCs. Each TMC must develop to serve their stakeholders and accomplish their particular mission. While the components and infrastructure may be similar across TMCs, this foundation can be utilized in many ways.

Urban TMCs are typically focused on freeway management. Incident detection, response, and management is at the heart of their systems and mission. Keeping the freeways moving is critical to their success. As a general rule, urban TMCs are typically larger and are more developed than their more rural counterparts. They've simply been at it longer. While TMCs are now being developed in small, more rural areas, the origins of active transportation management originated in the larger cities and that's where resources, time, and expenditures have been focused. The benefit however to newer, more rural TMCs is the wealth of knowledge and understanding available to shortcut the learning curves and reduce the timeframe from concept to operations.

Urban TMCs may also have established a number of working relationships with other agencies. It is not uncommon to see facilities where traffic operators, transit services, and police or emergency dispatchers are co-located—sometimes in the same building, sometimes in the same room. Newer facilities often feature expansive video systems that provide capa-

bilities to multiple agencies. There are typically a number of specific job categories and responsibilities and a hierarchical management structure for responding to a situation on the roadway.

By comparison, rural TMCs are generally smaller facilities. In fact, it's not uncommon for a rural "TMC" to be a computer in a room or a laptop in a common area. There may not be an expansive infrastructure and the focus of the agency may be different. While urban TMCs focus on freeway management and mobility, rural TMCs may focus on arterial street performance and signal systems. In a rural setting, agencies may not be co-located, but the management structure is typically less rigid and one person may do it all.

Despite the differences, both urban and rural TMCs can benefit from this manual. In particular, the main concept of this chapter, performance measurement, is a valuable tool and asset for any TMC, no matter how small or large, rural or urban. In fact, performance measurement has been recognized as a vital tool for smaller communities. In many of the sections that follow in this chapter, situations particular to the rural or small TMC are explicitly noted.

6.6. The Performance Measurement Process

Chapter 5 introduced the concept of a performance measurement (also called performance monitoring) process. Before proceeding to talk about the overall process, we should first establish exactly what a performance measure is. While the wording varies, a commonly accepted description of performance measurement is:

> "the use of statistical evidence to determine progress towards specific defined organizational objectives." (1)

Said another way, performance measures allow decisions to be made based on data gathered with scientific tools and approaches. It therefore follows that a performance measurement process is a systematic methodology that uses performance measures as a primary data source.

A performance measurement system is an on-going process, not a one-time event

However, performance measurement is *not* simply the process of collecting data and seeing if a threshold or value has been met. Rather, performance measurement *is* an overall management system which allows an agency to collect and evaluate information for the purpose of achieving goals, increasing efficiency, and meeting customer expectations. In terms of a TMC, the use of a systematic performance measurement process can help answer and address the following questions:

- How well are we doing in operating our roadways and transportation system?

- Are we meeting our goals?
- Are our customers satisfied?
- How can we improve our communication to our customers?
- Where are improvements necessary?

Are there opportunities for a tighter link between operations and other aspects of transportation, such as planning?

It should also be noted that performance measurement is applicable to a wide range of agency actions, not just the operations of any particular roadway. In fact, performance measurement has long been a key component in diverse transportation activities such as planning, maintenance, pavement and bridge management and more. In reality, the area of operations has lagged many of these other areas in the utilization of performance measures.

Performance measurement is not new. In fact, the formalized evaluation concepts first originated in the 1940's and 50's, with the push for Total Quality Management (TQM). TQM is a management philosophy which aims to integrate all organizational functions to focus on meeting customer needs and organization objectives. The roots of TQM were advanced in the United States, by Dr. W. Edwards Deming, an American statistician. Initially, Deming applied his techniques to improve the quality of military products during World War II. After the war, Deming taught TQM techniques to Japanese industries, most notably, the automobile industry.

Performance measurement concepts are based on Total Quality Management which have been applied in a business setting since the 1940's.

Although American industries were somewhat slower to establish TQM programs, over time, the concepts have caught on and have been implemented as part of standard business practices. Perhaps the step that best highlighted the use of performance measurement as a scientific and systematic assessment tool was a benchmark study released by the federal government in 1997. (2) This study advocated the use of performance management across all federal agencies and provided an overview, best practices summary, and framework to assist in that process.

The next several sections will allow the reader to develop an understanding of the performance measurement process as well as its application to the area of operations. Key to the understanding of these concepts is that performance measurement should be a systematic ongoing component of TMC operations. Although there are challenges to establishing and maintaining a performance measurement there can be substantial benefits. This section of the manual concludes with a checklist for defining and establishing a performance measurement process for a TMC.

6.6.1. Challenges of Performance Measurement

It is perhaps an obvious statement to state that any system has its challenges, in both implementation and use. Performance measurement is no different. The biggest challenge of performance measurement, when applied to operations, is that we are behind the curve of both other professions and other areas of the transportation profession.

There are several reasons for this lag. First, looking at the historical context of evaluating operations, the traditional indication of highway mobility and performance has been Level of Service (LOS). LOS is identified and calculated using procedures outlined in the Highway Capacity Manual (HCM). LOS identifies broad ranges in traffic flow and is not responsive to many indicators of current performance, especially on a smaller scale. LOS doesn't directly translate to concepts such as travel time, incident detection and clearance or other more targeted measures.

In addition, the concept of LOS is geared more towards the transportation professional. However, much of the information that the industry needs to convey must go to groups other than transportation professionals. The traveling public has no basis or understanding of differences in LOS levels. As such, indicators of performance that are more explicit and more easily understood are necessary. In fact, the indicators used to discuss mobility ad performance may change for different groups.

Finally, the use of performance measurement requires a large amount of data, both real-time and historical, which many agencies are only recently beginning to collect and keep for this and other purposes.

6.6.2. Benefits of Performance Measurement

Despite the challenges listed above, performance measurement can offer a number of significant benefits to transportation operations. In particular, operations is an area that is highly visible to our customers, the traveling public. While a motorist might notice pavement conditions a reduction in a bridge weight limit or some other type of measure, items such as congestion, increased travel times, incidents, blocked routes and more are attention grabbing and something that public has shown they care about.

Performance measurement keeps a TMC focused on their primary goal

The real benefit to an effective performance measurement system is the capability to keep the agency (or TMC) focused on their core mission. The primary focus should be on meeting customer needs and expectations, which typically translates to items such as mitigating congestion, reducing travel time delay, clearing incidents more quickly and provided reliable travel time estimates.

In general, performance measurement can provide benefits in multiple areas, including:

- Accountability
- Efficiency
- Effectiveness
- Communications
- Improvements over time
- Future planning

Accountability identifies if resources are being allocated to the priority needs. The desired effect is to achieve more informed decision making. One measure of efficiency examines the output for any given level of input. A typical example might look at the staff necessary to provide a given level of management and whether improvements in the process can reduce staffing needs, save costs or free up infrastructure for other uses.

Effectiveness typically measures a shift in an agency's approach. By using performance measurement, agencies have been able to shift their thinking. Instead of recording how many incidents took place in a given timeframe, the important concept shifts to questions such as: Has there been a reduction in incidents? Has there been a decrease in the average time of each incident?

Improving communication is perhaps an obvious or self-explanatory benefit of performance measurement. By focusing on primary goals that are important to the customer base, and identifying the appropriate information to convey results, communications can't help but to be improved.

Identifying improvements over time is another obvious benefit of a systematic evaluation process. By collecting and utilizing data in support of an on-going process, trends can be identified and long-term monitoring put into place. The feedback from these mechanisms can allow for the refinement of programs and services, both internal and external.

As a final benefit, performance measurement can't help but impact on future planning. As detailed above, the information gained from on-going focused evaluations allows for refinements. These refinements can be planned for and accomplished with greater accuracy and efficiency than was possible without a performance management system. Additionally, the availability of a solid basis for future plans may lead to an increase in the dollars available for operational improvements.

6.6.3. Understanding the Process

Illustrated in Figure 6.1, a performance measurement process can be formalized in nine steps, as identified below:

1. Identify the critical activity
2. Identify the goals and objectives of the activity

3. Develop a set of candidate performance measures
4. Identify performance targets
5. Identify uses of performance measures and potential audiences
6. Identify data needs and requirements for analytical tools
7. Establish data collection and evaluation procedures
8. Compare actual performance to targeted goals
9. Determine corrective actions or progress needed to achieve goals

<Figure 6.1 to be developed in Draft 2>

Step 1 – The first step of the process is basically a selection tool. The concept is to select a single activity that a TMC performs, focus on establishing the on-going performance measurement process for that activity, then return to step 1 and repeat it for another activity.

Step 2 – Every activity has goals and objectives that can be defined. As an example, if the activity is incident management, a typical goal may be to ensure the timely emergency response to incidents. Notice that the goal sets forth the large-scale vision. A corresponding objective may be to reduce the incident detection time. Another objective in support of the same goal may be to reduce the incident verification time. Take note that objectives tend to be more specific and focus on a particular aspect towards achieving the goal.

A performance measurement process has 9 distinct steps.

Step 3 – The identification of performance measures follows directly from the goals and objectives. Continuing with the example from Step 2, a performance utilized in the evaluation would be the current average incident detection time. Note that this performance measure may be stratified by type of incident, location, time of day or other variables that would provide a more detailed understanding of the system's response.

Step 4 – The identification of performance targets goes hand-in-hand with Step 3 above. Continuing with the example of incident detection, a specific performance target would be to reduce, by 25% from current levels, the incident detection time, within a timeframe of one year.

Figure 6.2 provides a detailed illustration of Steps 1-4 and shows the logical progression from vision (Step 1) to detailed and measurable targets (Step 4)

<Figure 6.2 to be developed in Draft 2>
Figure will be similar to Figure 2-3, page 2-6
NCHRP 8-36, Version 1 report

Step 5 – Any performance measure could be used in a variety of settings, but there are certainly measures that are most appropriate to particular audiences. A measure that is time based is easily understood by a non-technical audience and can be presented in a variety of methods. On the

other hand, measures that are based on rates, such as percent travel delay reduction per 100 million vehicles miles traveled (VMT), may be much more difficult to visualize and effectively display to a non-technical audience. The concept behind step 5 is simply to examine the list of measures and ensure that have information that can easily and quickly be understood by the target audience. It is also important to realize that there may be multiple audiences, including such diverse groups as politicians and city leaders, the general public, agency management, planners and engineers. Each group has a different need for information and a different capacity for evaluating the information presented to them. Understanding those facets and how your performance measures support those presentations is the outcome of this step.

Step 6 – A detailed discussion of the data needs for performance measurement takes place in section 6.9. The concept, at this step in the process, is to identify exactly what the data requirements are for any given measure. How much data? From what locations? How often? Can it be used "raw", or does it have to be processed? How must it be processed? Does the data need to be stored? For what period of time? What is the reliability of the data? These questions and more, can be used to establish detailed technical requirements for the data needs to support performance measurement.

Step 7 – Following directly from Step 6, a solid plan for data collection is the result of this step. Whereas Step 6 identified the data need (e.g, 5 min vehicle counts), this step identifies the source and mechanism for obtaining that data (e.g. automatic traffic counters at multiple locations along the freeway. Data stored in 5 minute bins in flat files and transmitted automatically, on a 24 hour cycle, to the TMC.) This step would also identify the specific tools and techniques that may be necessary to produce the final measure.

Step 8 – Perhaps the simples of steps in the process, this phase of the system compares the results of Step 7 to the desired results detailed in Step 4. An explicit categorization of the comparison results should be made, including date, time, overall result, measure, measure value, target, and difference between the value and target. This level of detail is an important input to Step 9 in the process.

Step 9 – Perhaps the most nebulous of all the steps in the process, Step 9 seeks to identify what, (if any), remedial actions are needed to continue to push the performance measures towards their targets. In essence, Step 9 becomes a planning or brainstorming exercise. How can incident detection time be reduced further? Could additional sensors provide for a more rapid analysis of the system response? Where should they be placed? How much will they cost? These and other questions can be utilized to

analyze the overall system response, evaluate shortcomings, and identify solutions to address those shortcomings.

A critical concept to understand is that even though Step 9 is the final step in the sequence, the process is an on-going and iterative evaluation methodology. This is perhaps best illustrated by the feedback arrows in Figure 6.1, which direct the reader back to other steps in the process, depending on the needs.

6.7. Types of Performance Measures

There are thousands of potential measures that an agency or TMC can utilize in the process of developing a performance measurement system. In fact, there are so many, that it is easy to get overwhelmed by the magnitude and to lose sight of the big picture. Remember, that the big picture is to choose measures that support the on-going, systematic evaluation of progress towards goals. Unfortunately, wading into the sea of performance measures in search of the perfect catch is a somewhat daunting task!

To help prepare you for that process, this section takes a look at some of the issues surrounding individual performance measures. We'll first examine what makes a good measure. This establishes a foundation for looking at individual measures or groups of measures and being able to assess their benefit to your program. Next, we'll quickly look at how measures can be classified. Classification simply helps us organize measures into groups or areas. Next, we'll bring all of the pieces together and look at the keys to a successful performance management system. Finally, the section will conclude with examples of typical performance measures.

6.7.1. What Makes A Good Measure?

First and foremost, a performance measure must measure or gauge the right item. It does so by focusing on the goals and objectives and determining if they are being met. A performance measure should focus on the end result—not the measurement itself.

The second trait of a good performance measure is that it is accepted. Generally, this means that the measure must be simple, understandable, unambiguous, and meaningful to the customer, regardless of whom the customer is. To best accomplish this, agencies may well use different measures for different customers.

The third trait is that performance measures must be responsive and/or sensitive to the data they are measuring. They do this by clearly showing any trends, minimums or maximums. A performance measure that is insensitive to these events within the data will not be meaningful to the customer because it can not accurately depict the progress towards the system goals.

The fourth trait of a good measure is that it is appropriate. Judging the appropriateness of a selection is typically done in two ways. First, the timeframe must be suitable to the desire. If the desire is to determine a percent reduction in incidents, the measure must look at a lengthy analysis period, such as a day, week, month, or even a year. Reporting on a timeframe of minutes or even hours, would make no sense and wouldn't be appropriate, for this measure. Second, the measure must be geographically appropriate. Measures can be directed towards a point, a segment, and entire facility or travel corridor, and even a region. A reduction in travel time wouldn't make sense at a point location, but might for a corridor or regional perspective.

A fifth and somewhat arguable trait is that a good performance measure should be supported by economical data collection. Measures that require large and expensive data collection are not likely to be determined very often, due to time and/or budgetary constraints. This makes the measure untimely and insensitive to smaller changes, and ultimately will not convey meaningful results. At the same time, TMCs should recognize that it is ok to stretch beyond the current practice and find and collect additional data sources, if the performance measures can provide meaningful results. This trait is arguable as many agencies have fallen into the trap of only looking at measures that can be supported by data they already collect. This can hinder effective evaluations and often results in choosing measures that don't support the stated goals.

6.7.2. Input and Output Classification

Performance measures can be categorized in any of a number of ways. The main use of classification systems is often to simply provide some organization to the long list of measures. In and of itself, classification provides no additional benefit to any particular measure; it simple helps you, the practitioner, organize measures in effective groups to support your needs.

One of the simplest methods for classifying performance measures is identifying them as an output, outcome, or input measure.

An outcome measure is primarily subjective. It provides information or an assessment on the results obtained from carrying out a program or activity. By comparison, an output measure is primarily objective and is typically the result of a tabulation or calculation. Output measures are most often numerical in nature.

Another way of expressing these same categories is that an outcome measure typically looks at the effectiveness of something. Has the situation changed? Has a program improved? What has been the progress towards an agency goal? An output measure typically looks at efficiency.

What rate of change was seen? What percent reduction was created? What are the numbers associated with each activity?

The third category is measures related to inputs. While output and outcome measures examine the results, input measures exam the resources available to carry out a program or activity.

The key to a successful program is not to rely on a single type of measure. In all likelihood, there will be multiple measures of each type utilized in any on-going program.

6.7.3. Goal Based Classification

Another typical classification used to organize performance measures is to group them according to their general goal. Mobility based measures, as one example, reflect the ease or difficulty of making a trip. Classifying performance measures based on their goal area can help provide continual focus on agency or TMC goals. The list of goal areas typically used in this type of classification include:

- Accessibility – ensuring convenience and or right-of-entry to customers.
- Mobility – the relative ease of difficulty of making a trip.
- Economic Development – the cost, economic health, and vitality of the transportation system.
- Quality of Life – the sense of community desires and customer satisfaction.
- Environmental and Resource Conservation – the assets saved or expended, either natural or man-made.
- Safety – levels and rates of incidents or other occurrences.
- Operational Efficiency – productivity, manpower, financial resources, etc.
- System Condition and Performance – physical conditions, service ranges, etc.

It is not uncommon for a goal based system to use a secondary classification scheme. Mobility may be broken down into passenger or freight mobility. Safety could be broken down into roadway, rail, transit, parking, freight, and more. Note that the secondary classification areas may not be consistent or common across all of the goal areas. To make things even more interesting, classification schemes can be intermingled, resulting in (as an example), a set of output based performance measures for freight mobility.

6.7.4. Keys to a Successful Program

Over time, a number of keys have been identified to have a successful performance management program. These keys, listed below, are not set in stone, but provide some guiding principles to help organizations navigate through the chore of picking appropriate measures. The keys listed below is also not an exhaustive list from the literature, bur rather a compilation of those items and advice which are commonly accepted and indisputable.

- Keep the number of measures manageable – Don't be afraid to include measures when significant, but exclude measures that are merely interesting and not directly relevant.
- Use a balance of measures – Provide both output and outcome measures. Determine the critical areas of focus in your TMC and select measures for each area. Remember that some measures are more suited to a particular audience and ensure that the selection of measures can adequately convey understanding to each group of stakeholders.
- Be flexible – TMCs, especially new ones, should be prepared to experiment with performance measures, in order to find the right mix and set the capture and support the specific operating environment.
- Go beyond the basics – While it is recognized the simplicity and ease of measurement are attractive characteristics, especially to a new TMC, an agency should not shy away from the "hard" issues, such as areas that are hard to quantify or where data may be difficult to obtain. This pushes a TMC to grow and increase its capabilities and ultimately provides for a better service to the stakeholders.
- Establish regular reviews – The performance measurement process should recognize the need for regular review. While the framework provides iterative loops, a TMC must embrace this need. Regular reviews of performance measures can add, delete, or revise measures, identify additional data sources, refine the presentation of measures to stakeholders, and ensure a continued focus on operational goals.

The primary key to a successful program is simply to get started!

6.7.5. Examples of Performance Measures

There are quite literally thousands of performance measures identified in the literature. A comprehensive compilation of those measures is well beyond the scope of this manual. The list below is but a small sample of measures that can be used by a TMC. This sample listing is intended to merely provide the reader with an awareness of the diversity of available measures. It is beyond the scope of this manual to suggest specific measures for a TMC.

The sample measures below have been stratified according to the goal classification system presented in section 6.7.3. This list includes measures which are both outcome based (examine satisfaction levels) and out-

put based (provide a quantitative assessment). It is also possible that measures may support more than one goal area and so may be listed twice.

- Accessibility
  - Average travel time
  - Average trip length
  - Model splits
- Mobility
  - Vehicle miles of travel by congestion level
  - Travel time under congested conditions
  - Delay per vehicle mile of travel
  - Delay due to incidents
  - Lost time due to congestion
  - Annual hours of delay
  - Increase in system reliability
- Economic Development
  - Jobs supported
  - Jobs created
  - Economic cost of accidents
- Quality of Life
  - Perceived satisfaction with commute times
  - Perceived improvements in safety
  - Lost time due to congestion
  - Change in vehicle emissions
  - Accidents per vehicle miles traveled
  - Ease of connections to inter-modal transfer points
- Environmental and Resource Conservation
  - Tons of pollutants emitted
  - Fuel consumption per vehicle miles traveled
  - Air quality rating
  - Modal splits
- Safety
  - Fatalities per vehicle mile traveled
  - Number of highway fatalities
  - Average duration of incidents
  - Average incident detection time
  - Average incident response time
  - Customer perception of system safety
- Operational Efficiency
  - Public expenditures on transportation system
  - Savings to taxpayers from incident management
  - Average travel cost per mile
  - Change in congested travel
  - Change in delay due to congestion
- System Condition and Performance
  - Lane miles of facilities under active management

- Pavement serviceability rating
- Volume to capacity ratios

6.7.6. Performance Measures for the Rural Environment

Earlier sections of this chapter identified and discussed some of the differences in TMCs developed for urban or rural settings. In particular, the use of performance measurement, the choice of performance measures, the data collected, and communications to stakeholders may be significantly difference in smaller areas. The following list identifies some of the major differences and contains recommendations for where smaller communities should focus their efforts.

Rural TMCs may have special needs and a different focus than their urban counterparts

- In smaller communities, planning agencies often lead the charge of conducting operational performance measurement.
- Operations in smaller communities are typically focused on major arterials and signal operations.
- Mobility measures are likely to be of greatest interest to smaller communities.
- Because the typical activities of involved agencies in smaller communities involve planning, performance measure focusing on the facility-level are likely to provide the best starting point.
- There are currently only a few small communities using travel time reliability measures.
- Performance measures looking at operational efficiency measures should be of interest to small communities.
- Most small communities are interested in measures that are readily understandable by the general public.
- Few small communities have developed a a dedicated performance measurement system.
- In smaller communities, accessibility measures are not critical.

6.8. Establishing Performance Measurement Thresholds

A threshold can be thought of as a bar or even a line in the sand. The objective is to reach the bar or cross the line. The line in the sand may be 15% fewer crashes or reducing average trip delay by 5%. Regardless of which measure is being utilized, a threshold serves as the evaluation point for determining the progress.

Without thresholds, there is no real basis for choosing what to measure, how to assess it or what action to take. Establishing reasonable thresholds is a critical step in the performance measurement process.

The key consideration is reasonable. Targets should be stretching and challenging to an agency or TMC, but not unrealistic. It wouldn't be prudent to set a threshold of a 100% reduction in accidents on the freeway. It may however be reasonable to establish a target of 5%. When that target

has been reach, the iterative nature of performance measurement will lead the TMC to establish a new target, therefore pushing for continuous improvement.

As with the previous section pertaining to the performance measures, it is beyond the scope of this manual to offer suggestion on specific thresholds that an agency should establish as part of their overall system. However, what can be offered are some simple guidelines for establishing appropriate thresholds.

Thresholds should be:

- Realistic
- Specific
- Challenge, but not punish the agency
- Achievable (lest staff feel they are out of reach and doomed for failure)

In additional, thresholds should include a timeframe for completion. An open ended timeframe doesn't promote focused and consistent efforts for meeting targets

6.9. Collecting Performance Data

<This section is still under development as of this draft submission. Salient points are identified below and will be incorporated into the text for Draft 2.>

Provide specific guidance.

TMC ops manual should identify the following minimum components for data collection in support of a performance measurement process.

Identify:

- Data to be collected
- Frequency of data collection
- Schedule of data collection
- Location(s) of data collection
- Data collection responsibilities
- Data analysis needs (cleaning and quality screening)
- Data analysis responsibilities
- Database or historical record keeping requirements

Methods of collecting data include:

- Automatic collection

- Regular (manual) collection
- Periodic collection
- Random sample collection
  1) small-scale samples such as travel time runs using the floating car method;
  2) simulation modeling data rather than direct measurement.

Metadata use

Data Fusion needs (e.g. TMC responses with incident logs, weather data, work zones, and special events.)

Identify data sources external to the TMC

Small / Rural Notes:

> Typically, neither planning nor operating agencies have all of the resources necessary to support intensive data collection efforts solely for performance measurement. However, data can generally be found through alternative sources from the city, county, and state traffic count programs; traffic signal system data; and in some cases special corridor studies in the form of travel time and delay runs.

6.10. Processing and Reporting Performance Data

> *<This section is still under development as of this draft submission. Salient points are identified below and will be incorporated into the text for Draft 2.>*

Provide specific guidance

Numerous methods of communicating information:

- Web sites
- Newsletters
- Media
- Technical reports
- Graphic displays
- Before/After Analyses

In general, when communicating to the public, one recommended approach is:

- Start with the message -identify reason for communication
- What is the range of actions
- How can progress be measured
- What is the progress

- Where did the data come from
- What are the next steps

6.11. References

1. Performance Measures for Operational Effectiveness of Highway Segments and Systems. NCHRP Synthesis 311. Transportation Research Board, National Research Council., Washington, DC, 2003.

2. "Serving The American Public: Best Practices in Performance Measurement" National Performance Review by Vice President Al Gore. June 1997. http://govinfo.library.unt.edu/npr/library/papers/benchmrk/nprbook.htm Accessed October 29, 2002.

7. CASE STDUY: NORTHERN VIRGINIA SMART TRAFFIC CENTER

<Additional case studies will be provided in Draft 2.>

7.1. Introduction

The Northern Virginia (NoVA) District of the Virginia Department of Transportation (VDOT) operates one of the department's three existing Smart Traffic Centers (STC). The STC is similar to a Traffic Management Center concept, and is situated in a very urbanized and congested area of metropolitan Washington, focused on management of the interstate route freeways, overseeing more than 100 miles of roadway. It operates on a 24 hour/7 day a week schedule.

The NoVA STC operations include: congestion mitigation with extensive reversible HOV lane operations, incident management, and traffic planning. The elements of the system include:

- 109 cameras
- 222 variable message signs
- 24 gates on I-66 HOV lanes for use during peak travel hours
- 21 gate groups on I-95/I-395 for reversible HOV lanes
- 25 ramp meters for inside the beltway on I-66 and I-395
- 30 lane control signals
- 23 vehicle classification stations
- 177 controllers with sensors and loop detectors
- ATMS software
- an automatic incident detection system
- a meteorological weather satellite to monitor rain, snow and ice conditions
- 2 Highway Advisory Radio sites
- 3 operator workstations, each dedicated to specific Interstate freeway sections
- 2 call taker workstations
- enclosed supervisor work area

The Operations Manual used for the NoVA STC is called the "Standard Operating Procedures" (SOP). The manual is very comprehensive with 157 pages. The operations staff in the STC are comprised of traffic controllers and call takers, with supervisors.

A regional ITS architecture, called the Northern Virginia Regional Architecture, presents the VDOT Northern Virginia District's interfaces to other transportation systems within and adjacent to the region. The NoVA STC must follow operational concepts that conform to the architecture.

7.2. Contents of Manual

Each section of the SOP is described in the order which it is published in the SOP.

7.2.1. Introduction

This section describes the purpose of the SOP, the layout of the SOP, and how updates are made. The purpose is to act as a reference guide for situations when supervisors are not present.

In order to assure authenticity of the material, each section has a validation system presented in a table at the beginning, followed by another table with revision information. It is explicitly noted that the SOPs must remain at the each workstation.

7.2.2. NoVA Operational Concepts

This section is focused on the overall responsibilities of the traffic controllers and call takers. The operations are put in context by stating the STC objectives, and the operations division organizational chart, before the STC responsibilities are detailed. It has a map showing the STC coverage area.

The responsibilities include a description of all the tools used in the STC. Responsibilities include use of a checklist (detailed in Section 6), fault monitoring of equipment, and fairly detailed incident management procedures. Finally, the different responsibilities for each of the three operations workstations and the call taker workstations are described. This avoids conflicting operations, plus protocols for coverage if a workstation is not staffed.

7.2.3. Administrative Procedures

This section does not address traffic operational issues, but rather procedures to better manage and keep the STC facilities working properly. Responsible procedures detailed in this section include: cleanliness, maintaining supplies (office and system-related equipment), subsystem crashes, backup procedures, and facility security.

Subsystem crashes are handled by a specific process presented in steps to follow to restore the system. If a step does not work, the next step must be taken. The process includes ultimately contractor support, with information on who to call and their number, and a second designated person if the first person does not respond in 15 minutes. System backups are detailed in a similar stepped process manner, including contacts is the process does not work properly.

The facility security addresses access codes for entering the controlled space in the building of the STC. It even addresses how visitors can access the STC.

7.2.4. Telephone Procedures

This section is rather brief, but very considered very important due to the frequency and nature of calls to this nerve center. Items include etiquette, note taking, and protocols and instructions for transfers. Communications is critical to the STC operations, and mishandled phone call can have serious consequences and embarrassment.

7.2.5. Internet Operations

Another very brief section, but focused on restricting misuse of Internet access. As in any work office environment, workers abusing Internet access is a serious concern. Yet, the Internet is a powerful tool for information access. The benefits are recognized, especially email, but warnings are provided regarding interferences with work responsibilities.

7.2.6. Daily Operations

This section describes the shift hours and staffing for daily operations, procedures for taking a break, and the shift procedures checklist for each workstation assignment. Procedures for taking a break identify the protocols that must be followed, as continuous coverage of managing the system is critical.

Copies of the checklists are presented in this section, unique to each workstation and each time shift. The checklist requires a name and date at the top, following by a list of scheduled operations with specific times for each. These operations include system maintenance activities and specific traffic operations (i.e. HOV controls, information dissemination). At the bottom of the checklist is a note with a brief description of other duties that are not time specific, namely system monitoring and incident management.

The night shift checklist is similar for all workstations, as specific traffic control responsibilities of specific Interstate operations for commute periods are not needed. The weekend checklist are similar for each workstation too, but include spaces for logging of any traffic control operations that may be required to be activated and non-recurring events. A special log is included for operations of moveable bridges too.

The checklists are excellent means to avoid operations mistakes that could lead to serious hazards to the traveling public.

7.2.7. Incident Management Procedures

This section describes procedures for various types of incident, considered a core duty of the traffic controller, in specific details. Due to the extensive detail, the procedures are followed by a "Quick Reference Guide" which just simply list operational steps without detail. At the end is a list of potential agencies to coordinate activities, but no phone numbers.

The incident management procedures begin with methods for incident detection and verification, followed by notification of other agencies for response actions, including very extensive detail for notifying the media (what to say and what not to say). Then there are procedures for activation of field devices with conditional requirements, followed by notification of incident clearance.

7.2.8. Radio Operations

This section relates to operations of various radio equipment, including: VDOT two-way radios, emergency service scanner, and the Highway Advisory Radios (HAR). A reference to the governance by the policies of the various operating agencies of each piece of equipment and the FCC is made.

Items in this section include: radio "ten codes", channel numbers and call signs, protocols and radio usage etiquette, the phonetic alphabet, scanner utilization, and HAR. The HAR Procedures are very detailed, including general use, message development and format, and the locations of each HAR. Several example message formats for various incident scenarios and conditions are provided.

7.2.9. NoVA STC Monitoring Devices

This section identifies the field equipment that is operated from the ATMS and the respective procedures for operations. Equipment includes:

- CCTV
- HOV for I-66
- HOV for I-395/95
- Ramp metering
- Variable message signing

The section concludes with equipment malfunction procedures. This is the longest section.

7.2.10. NoVA STC External Systems

This section identifies equipment that is not part of the ATMS, but operable from the STC, with respective procedures for operations. Equipment includes:

- Information Exchange Network with agencies in the I-95 Corridor Coalition
- National Warning System operated by the Washington, DC emergency management
- Call Box System
- NoVA Pagers
- Woodrow Wilson Bridge operations
- Statewide database for tracking incidents

7.2.11. Roadwork Procedures

This section addresses STC procedures for various roadwork scenarios. These include:

- What to do upon notification of roadwork
- Information dissemination procedures related to roadwork
- Information dissemination procedures upon accident notification in workzones
- Information dissemination upon notification of roadwork time extensions
- Logging of roadwork activities
- What to do when roadwork overlaps commute peak periods

The overall theme is to provide timely information to key stakeholders and dissemination to traveler information services.

7.2.12. OZONE Alert Procedures

This section relates to actions the STC must take when a “code RED” ozone alert is issued. Activities include: initiating advisories to the public, sending e-mail messages to all VDOT employees, and placing appropriate messages on VMS and HAR. The manual identifies specific messages for each device.

7.2.13. Call Taker Procedures

This section describes the procedures taken by call takers in the STC. It is very specific actions to be taken, during normal working hours and off hours, that tries to be all encompassing for a variety of possible scenarios, including:

- Accidents/incidents
- Bridge maintenance repair
- Dead animal
- Debris in roadway
- Graffiti
- Vegetation obstruction
- Guardrail damage
- Damage to impact attenuators/glarefoil
- Roadwork lane closure notifications
- Manhole covers missing/removed
- Noise complaints
- Potholes
- Property damage
- Traffic signals
- Roadway signs
- Snow/ice complaints
- Steel plates
- Storm drains
- Overhead lighting
- Trees obstruction
- High water/flooding
- Wrecker requests

7.2.14. NoVA STC Operation Logs

This section covers the various reporting logs required to be completed by the STC. For each of the activities below, a brief description of the purpose of the form, when to fill out, and sometimes a copy of the form:

- Equipment failure
- VMS request
- Equipment repair request
- NoVA STC maintenance database
- Incident reports
- STC activity log
- Maintenance action request system
- STC snow/ice complaint
- Wrecker request

Each of these activities is seen as important enough to warrant documentation of logging, providing a record for future analysis.

7.3. Overview of Manual Effectiveness

Items to be addressed in Draft 2 include the following.

1. Relationship to other manuals, and agency policies and procedures.
2. The challenges in developing and updating the manual.
3. Key issues that have led to the successes of the operations manual.
4. Overall effectiveness of the manual.
5. Aspects of the manual that are most useful, and that need to be changed.
6. Lessons learned along with recommendations on manual development as it relates to the life-cycle of system development.

7.4. Summary

<Additional text will be added during Draft 2. Items that are unique to this manual will be highlighted.>

8. TMC MANUAL CHECKLIST

8.1. Introduction

8.1.1. Chapter Purpose and Key Issues

The purpose of this appendix is to provide a checklist of topics for a TMS / TMC Manual. Some sections of this appendix can be linked to discussions in prior sections of the Handbook.

8.1.2. Relationship to Handbook Document

This checklist if meant to support in a very specific manner the material provided in the Handbook. While much of the Handbook provides conceptual and procedural guidance on development of a Manual, this appendix supplements that material with quick descriptions of the topics to be included in the Manual.

8.2. Daily Operations

Components of an operations manual to support daily operations

8.2.1. Emergency and Other Contact Numbers

Quick reference for emergency situations

- Police, fire, EMS, motorist assistance patrols, PSAP
- Street maintenance, freeway maintenance
- Private information providers, media
- Other

8.2.2. TMC Emergency Plan

Quick reference for emergency action in the control room (not traffic management or homeland security issues).

8.2.2.1. Evacuation

8.2.2.2. Fire

8.2.2.3. Smoke

8.2.2.4. Flood

8.2.2.5. Communications Loss

8.2.2.6. System Shutdown

8.2.2.7. System Startup

8.2.2.8. System Failure Recovery

8.2.3. General Policies

Statement of general policies related to daily operation, security, administrative procedures, etc. Many of these policies may be stated in an overall agency Human Resources or other policy.

8.2.3.1. Documentation of Manual Updates

- Version and date of current manual
- Change Policy
- Update Status and Record

8.2.3.2. Procedure and authorization to change/suspend policy

8.2.3.3. Outside agency authority

8.2.3.4. Severe weather conditions

8.2.3.5. Authorization, scheduling, and handling of visitors

8.2.3.6. Citizen inquiry and service requests

8.2.3.7. Contact with Media and the Public.

8.2.3.8. System and Non-System Equipment

- General Office Equipment
- Operator Specific Equipment
- General Agency Property
- Telephone and Fax Usage

8.2.3.9. TMC Building Cleaning and Maintenance

8.2.3.10. Building Security

- Allowable access to the building
- Pass keys/keypads and controlled access
- Allowable access to control, communication, and equipment rooms

8.2.3.11. Organization Chart and Work Shifts

8.2.3.12. Organization Chart and Work Shifts

Documentation of reporting schedule and standard work shifts.

8.2.3.13. Other Workplace Policies

Miscellaneous policies such as those mentioned below are typically covered by existing agency policies but need to be modified to the TMC.

- Breaks
- Drug-free workplace policy
- Meals
- Nondiscrimination
- Overtime
- Smoking policy
- Uniform and dress code

8.2.4. General System Operation

8.2.4.1. Management Center Functions

General TMC functions. Refer to more detailed operations and functions in subsequent sections.

8.2.4.2. Control Center Description

- Location

Street and mailing address, location within agency grounds, and latitude/longitude. Map of general area showing TMC location.

- Layout

General plan view layout of TMC building and detailed plan view of the control room

-Consoles
-Displays
-Voice communication devices
-Fire suppression
-Power source location

-HV/AC
-Data communications
-Network communications

- Personnel

Typical staffing including job titles and brief duties, designated supervisor for shifts. Operations, maintenance and supervisory personnel contacts (home, pager, cell)

- Hours Of Operation

Hours of operation for workdays, holidays, weekends, nights, special events, and emergencies.

- After Hours On-Call Roster

Contact numbers (home, pager, cell)

8.2.4.3. Remote Operation

Circumstances for remote operation, authorization, and designated personnel

8.2.4.4. Security Procedures

Control of access to interfaces and various levels of access

8.2.4.5. Maintenance Checklist

Routine maintenance checks and minor repairs that may be performed by operators

8.2.4.6. Coordination and Dispatch of Motorist Assistance Patrols (Freeway)

8.3. Operational Concepts – Freeway Management Systems

Overall concept description enabling user to visualize goals, objectives, and how the discreet parts fit together to accomplish those objectives

8.3.1. Goals of the Traffic Management System

Concise statement of goals and objectives of the TMS and how general components work together (Detection, response, data collection and storage)

8.3.2. Interagency and Inter- Jurisdictional Coordination

Description of need for interagency and inter-jurisdictional cooperation and coordination with other stakeholders.

8.3.3. Malfunction Response

Dispatch maintenance, logging, testing

8.3.4. Traffic Monitoring

Description of traffic monitoring devices such as:
- Speed Detector Monitoring and Response
- Closed Circuit Television (CCTV)
- Recording Video Images
- Road Construction Monitoring
- Highway Maintenance Activity

8.3.5. Traffic Response

Response to planned or unplanned events, general description of functionality

8.3.5.1. Dynamic Message Signs (DMS)

Overview of uses of DMS
- DMS Message Priority
- Display of Travel Times
- Blank Signs
- Operation of DMS by Law Enforcement Personnel

8.3.5.2. Traffic Diversion

General description of when diversion is warranted and policy on diverting to specific roadways
- Full Freeway Closure
- Partial Freeway Closure
- Diversion to Roadways Not Under the Jurisdiction of Agency

8.3.5.3. Highway Advisory Radio (HAR)

8.3.5.4. Lane Control Signals (LCS)

8.3.5.5. Ramp Metering

8.3.6. Field Devices – Freeway Systems

Functional description and locations of field devices in TMS

- Closed Circuit TV (CCTV)
- Communication Media
- Detectors
- Dynamic Message Signs (DMS)
- Highway Advisory Radio (HAR)
- Lane Control Signals (LCS)
- Ramp Meters
- Other

8.4. Control System Operation Procedures-Freeway Management Systems

This section will depend greatly on the individual system but typical functions can be modified or deleted if not applicable

8.4.1. System Start-Up Procedures

8.4.2. System Shut Down Procedures

8.4.3. Operator Interface

Typical pictures of interfaces where applicable Field Communication

- Closed Circuit TV (CCTV)
- Dynamic Message Signs (DMS)
- LCS
- HAR
- Police Communication

8.4.4. Incident Management Procedures

Procedures will vary widely among agencies but typical example will be provided. Response will include both actions to be taken to respond as well as notification of other agencies

8.4.4.1. Reported Incidents

8.4.4.2. Detected Incidents

8.5. Operational Concepts – Traffic Signal Management Systems

Overall concept description enabling user to visualize goals, objectives, and how the discreet parts fit together to accomplish those objectives

8.5.1. Goals of the Traffic Signal Management System

Concise statement of goals and objectives of the TMS and how general components work together (Detection, response, data collection and storage)

8.5.2. Interagency and Inter-Jurisdictional Coordination

Description of need for interagency and inter-jurisdictional cooperation and coordination with other stakeholders**.**

8.5.3. Control Area

Description of control area, number of signals, map, system boundaries, jurisdictional boundaries.

8.5.4. Traffic Signal Operations

Description by region/sector: isolated, pre-timed, traffic responsive, system coordination, adaptive operation, etc

8.5.5. Agency Responsibilities in Developing Signal Timing

Who within agency determines signal timing parameters, schedules, update frequency, etc.

8.5.6. Field Devices Traffic Signal Systems

Functional description and locations of traffic signal field devices in TMS:

- Signal Heads
- Controllers
- Detectors
- LCS
- DMS
- CCTV
- Communication Media
- Other

8.6. Control System Operation Procedures-Traffic Signals

This section will depend greatly on the individual system but typical functions can be modified or deleted if not applicable

8.6.1. System Start-Up Procedures

8.6.2. System Shut Down Procedures

8.6.3. Operator Interface

Typical pictures of interfaces where applicable

- Operator Console
- Signal System Interface
- Field Communication
- Closed Circuit TV (CCTV)
- Dynamic Message Signs (DMS)
- Lane Control Signals (LCS)
- Police Communication

8.6.4. Incident Management Procedures

Procedures will vary widely among agencies but typical example will be provided. Response will include both actions to be taken to respond as well as notification of other agencies.

8.6.4.1. Reported Incidents

8.6.4.2. Detected Incidents

8.7. TMC Maintenance Procedures

Routine maintenance to be performed by operators. Anything beyond that would be performed by contract or agency maintenance personnel**.**

8.7.1. Routine Maintenance

Typical daily checks, adjustments, and component exchange

8.7.2. Preventative Maintenance

Scheduled by agency maintenance personnel or contractor

8.7.3. Spare/Backup Equipment

Inventory of spare and backup equipment. Listing of vendors and suppliers**.**

8.7.4. Emergency

Notification procedures for major failures

8.7.5. Agency Maintenance

Listing of maintenance to be performed by agency personnel.

8.7.6. Contract Maintenance

Criteria for calling in contract maintenance, phone, fax, and pager listings. Authorized agency personnel to authorize repairs**.**

8.8. System Operations Logs

Historical logging procedures (manual and automated) as determined by management within capability of specific system.

8.8.1. Incidents and Events

Planned and unplanned events, road closures, etc

8.8.2. Operations

Operations periods, on-line/offline times, manual intervention, etc

8.8.3. Maintenance

Malfunctions, outages, resolution of problem, etc

8.8.4. Citizen Requests

Requests for service (e.g., signal timing, DMS displays).

8.9. System Reports

System evaluation operation parameters, etc.

8.10. Traffic Data Collection and Storage

Historical data, analyses, etc.

8.11. Risk Management

Guidance of what types of data to store and for how long in response to agency risk management policies.

8.12. System Documentation

Listing of available documentation and where it is stored or filed, procedures to update.